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Focused Feasibility Study Report

Lake Calumet Cluster Site Chicago, Cook County, Illinois

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List of Acronyms

ARARs	applicable or relevant and appropriate requirements
BERA	baseline ecological risk assessment
BGS	below ground surface
Clayton	Clayton Group Services, Inc.
cm/sec	centimeters per second
COPC	contaminant of potential concern
CPECs	contaminants of potential ecological concern
CSM	conceptual site model
CWA	Federal Clean Water Act
DOT	U.S. Department of Transportation NPDES requirements (40 CFR 122),
EcoTox	ecological and toxicological
E & E	Ecology and Environment, Inc.
EEEI	Ecology and Environment Engineering, Inc.
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
EPCs	exposure point concentrations
ERT	Environmental Response Team
ESA	Federal Endangered Species Act
ET	evapotranspiration
FFS	Focused Feasibility Study
FML	flexible membrane liner
FWS	U.S. Fish and Wildlife Service
HDPE	high-density polyethylene
HEAST	Health Effects Assessment Summary Table
HHRA	human health risk assessment
HI	hazard indices

List of Acronyms (Cont.)

IAC	Illinois Administrative Code
IGA	intergovernmental agreement
Illinois EPA	Illinois Environmental Protection Agency
IRIS	Integrated Risk Information System
IROD	Interim Remedial Action Record of Decision
LCC	Lake Calumet Cluster
LFG	landfill gas
MWH	Montgomery Watson Harza
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OU1	Operable Unit 1
OU2	Operable Unit 2
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PRG	preliminary remediation goal
RAIS	Risk Assessment Information System
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RfDs	reference doses
ROs	Remediation Objectives
SFs	slope factors
SIC	Standard Industrial Classification
SLERA	screening-level ecological risk assessment
START	Superfund Technical Assessment and Response Team
SVOCs	semivolatile organic compounds
T&E	threatened and endangered

List of Acronyms (Cont.)

TACO	Tiered Approach to Corrective Action Objectives
TBCs	to be considered
TCLP	toxicity characteristic leaching procedure
TSCA	Toxic Substances Control Act
UCL	upper confidence limit
VOCs	volatile organic compounds
XRF	X-ray fluorescence

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Introduction

This document was prepared for the Illinois Environmental Protection Agency (Illinois EPA) under Professional Services Agreement Number HWA-1309, Amendment No. 17, dated February 18, 2006 between Illinois EPA and Ecology and Environment, Inc. (E & E).

Under this work order, E & E was tasked to develop a Focused Feasibility Study (FFS) Report for the Lake Calumet Cluster (LCC) site located in Chicago, Cook County, Illinois (see Figure 1-1). This FFS was prepared to identify potential remedial options that may be implemented as part of a proposed interim remedial action, which is intended to address buried and exposed waste on the site, as well as site surface water runoff that enters Indian Ridge Marsh.

Ecology and Environment Engineering, Inc. (EEEI), E & E's wholly owned, Illinois-licensed engineering subsidiary, developed this document. Additionally, the Illinois EPA is the lead agency, and the United States Environmental Protection Agency (EPA) is the support agency for this site.

1.1 Purpose and Organization of Report

This FFS Report was developed in accordance with applicable EPA guidance documents, including:

- EPA's *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites* (EPA/540/P-91-001); and
- EPA's *Presumptive Remedy for CERCLA Municipal Landfill Sites* (EPA 540-F-93-035).

This report is divided into six sections. Section 1 provides background information and summarizes the findings of previous LCC site investigations and reports. Section 2 screens potential remedial technologies, Section 3 develops comprehensive site alternatives, and Section 4 provides a detailed analysis of the alternatives

using EPA evaluation criteria. Section 5 provides a summary of the findings of the FFS, and Section 6 lists the references used in this document.

1.2 Background Information

1.2.1 Site Description

The LCC site is a group of several land and waste storage/disposal facilities located in southeastern Chicago, Cook County, Illinois (latitude 41°41'15.0" North and longitude 87°34'35.0" West at the Paxton II area). The site is approximately 87 acres in size and is bordered by the Paxton I Landfill to the north, Land and Lakes #3 Landfill to the west, the Norfolk Southern Railroad right-of-way to the east, and 122nd Street to the south. The LCC site consists of the following individual areas: Paxton Avenue Lagoons, Alburn Incinerator, U.S. Drum II, and an unnamed parcel. A site location map is presented in Figure 1-1, and an aerial photograph of the site with area features is presented as Figure 1-2. From 1900 to the 1970s, nearby industries deposited slag and other waste that raised the surface area to an elevation just above the water table. From 1940 to 1992, much of the area was used for unpermitted waste disposal. The contaminated runoff in the area impacts wetland soils and hydrology.

Current topography around the LCC Site is relatively flat, with the notable exceptions of Land and Lakes #3 Landfill and Paxton II Landfill. The flat terrain includes interspersed areas of slag, open waters and wetlands. The composition of the fill varies considerably, as evidenced by the uneven growth of vegetation and the fact that much of the area is inundated a significant portion of the year. There are limited surface drainage ditches, and no stormwater lines. The uppermost 15 to 20 feet contains an unconfined, contaminated aquifer.

1.2.2 Site History

More than a century ago, the Calumet region was the largest wetland complex in the Great Lakes area, but by the 1900s it became the heart of heavy industry for the upper Midwest. Currently, a combination of natural, industrial, and residential areas typifies the contrast found around Lake Calumet. Abundant wildlife (including many state and federally endangered species) live in remnants of a once-vast wet prairie system scattered among industrial facilities. Much of the wetland area that was not converted into active industrial or residential use was used for municipal, industrial, and chemical waste disposal. The economic decline of the steel industry during the last decades of the 20th Century left the Calumet area economically and ecologically degraded. Today, remnant wetlands and other natural areas remain, but they are interspersed among active and abandoned industries, slag piles generated by nearby steel manufacturers, and chemical waste disposal sites and landfills.

Prior to 1949, aerial photographs did not show any indications of activities at what is now the LCC site (E & E 1999). The site was mostly wetlands,

characterized by marsh-type vegetation and some open water. Activities up to the 1970s consisted primarily of a combination of what are described as "extraction" activities, which evidently refer to excavation and removal of soil materials from the site, and filling activities. The filling activities were first noted in the northwest quadrant of the site, and were described as the dumping of both solid and liquid wastes in this area. Drainage was noted to flow toward the eastern half of the site, which at the time was still a wetlands area.

Extraction and filling continued on the site through the early 1970s, at which time the entire site was disturbed, and fill occupied the full site north to south and over half the site from west to east. Liquids were noted to be draining in all directions, and standing pools of liquids were noted in the pit areas, which had been excavated and as yet unfilled.

Several investigations have been performed at the LCC site since the early 1980s. These investigations, which have identified soil, sediment, and groundwater contamination at the site, are discussed in more detail in Sections 1.3 and 1.4. A brief description of each of the LCC sites is presented below.

1.2.2.1 Alburn Incinerator

The former Alburn Incinerator (Alburn) site is located 0.5 miles east of Lake Calumet, 1 mile west of the Calumet River, and 1.25 miles north of the Little Calumet River. The Alburn Incinerator parcel encompasses approximately 35 acres. The Alburn site operated as a landfill from 1967 through 1977, and historic records suggest that the property received a large amount of slag material that raised the ground height above the existing surface water level. No details are available concerning the types and quantities of wastes buried during this period. In 1977, Alburn initiated hazardous waste incineration and hazardous waste storage and transfer operations. In 1979, the EPA issued a Resource Conservation and Recovery Act (RCRA) permit to Alburn for the operation of the incinerator. Alburn incinerated/stored hazardous wastes and sludge, including paints, thinners, varnishes, chlorinated solvents, styrene, ink, adhesives, waste oils, antifreeze, petroleum, naphtha, coal tar, and waste solvents. Site storage and disposal methods included landfilling, incineration, operation of a surface impoundment, and bulk liquid waste storage.

In 1982, Alburn had their permit revoked due to several RCRA violations. Alburn continued to accept bulk waste until January 1983. On July 5, 1983, two on-site drums exploded from heat expansion and a subsequent chemical reaction. EPA ordered an immediate removal action to remove all visible sources of hazardous materials from the site, including bulk storage tanks, drums, 5-gallon pails, and lagoon sludge. In addition, the top 6 inches of soil, assumed to be the most contaminated, was excavated, and the site received a partial cover. Illinois EPA conducted a follow-up soil sampling investigation in 1988 and 1989.

1.2.2.2 Unnamed Parcel

The Unnamed Parcel is approximately 38 acres in size and is located south and west of Alburn; the Unnamed Parcel is classified as an unpermitted landfill. It is believed that this area received various municipal, industrial, and chemical waste materials from approximately the 1940s through the 1960s. Now, much of the Unnamed Parcel area has little or no soil cap and is covered with perennial grasses, weeds, and wetland vegetation.

1.2.2.3 U.S. Drum II

The U.S. Drum II area is an unfenced, undeveloped area covering about 2.5 acres. Historic records suggest that as early as the 1940s, U.S. Drum II and the adjacent areas had been used as dumping grounds for industrial and municipal wastes. Currently, the surface level of the U.S. Drum II property is raised approximately 10 feet above the original natural ground level, due to the unauthorized land disposal. During the mid-1970s the site was used as a hazardous waste transfer and petroleum recovery facility until a fire occurred in July 1975. Operations at the facility were abandoned temporarily in 1976. In 1979, a waste drum temporary storage and transfer facility operated at the site. The waste transfer facility was shut down in 1979.

The Illinois EPA became aware of the site in the 1970s, when the property was used as a solvent recovery and waste transfer facility. In April 1979, a temporary restraining order was issued and operations ceased due to the discovery of 6,000 55-gallon drums, four open-dump lagoons of sludge and various wastes, 25 semi-trailers, and three bulk liquid trucks. The site ceased operations shortly thereafter.

Between October and December 1979, an estimated 34,100 gallons of liquid and semisolid wastes were removed from the property, and an estimated 1,750 drums were left on site inside earth berms. An EPA removal action occurred at the site from December 1984 through July 1985. During construction of a new access road, an additional 1,500 buried drums were discovered. The ends of the drums had been cut off or the drums had been punctured to allow the contents to drain into the ground prior to or at the time of burial. All observable drums, 435 cubic yards of contaminated soil, and 62,000 gallons of standing water were removed during the EPA action.

1.2.2.4 Paxton Avenue Lagoons

The Paxton Avenue Lagoons are located north of 122nd Street, southwest of the Alburn Incinerator and west of the Unnamed Parcel. Lake Calumet is located approximately 1 mile to the west. The Paxton Avenue Lagoons consisted of three lagoons, a berm composed of soil and crushed drums, and an area of oily soil. The lagoons were reportedly active during the 1940s, and a variety of chemical wastes from nearby steel mills were allegedly brought to the site. A large number

of drums are also alleged to have been buried. Illinois EPA samples collected in 1985 indicated significant levels of volatiles, semivolatiles, polychlorinated biphenyls (PCBs), and heavy metals. In 1990, Illinois EPA conducted an immediate removal action at the site of 60 drums of hazardous materials and 2,200 cubic yards of acidic soil. The lagoon area was capped with clay. The lagoons have been closed and fenced since October 1993.

1.3 Nature and Extent of Contamination

For this FFS, data obtained from the four most recent investigations has been used to define the nature and extent of soil contamination at the LCC site, which has been defined as Operable Unit 1 (OU1). It should be noted that addressing groundwater contamination as a remedial action is beyond the scope of this FFS and will not be addressed in this report. Groundwater, which for the LLC site is defined as OU2, will be addressed under a separate action. Groundwater monitoring is included as a component of each of the alternatives for OU1.

The four investigative reports used in the development of this section are:

- E & E, March 10, 1999a, *Results of Phase I Sampling Activities for the Lake Calumet Site*;
- E & E, November 30, 1999b, *The Nature and Extent of Contamination at the Lake Calumet Cluster Site*;
- Harza Engineering Company, May 2001, *Comprehensive Site Investigation Report, Lake Calumet Cluster Site: Alburn, U.S. Drum, and Unnamed Parcel Areas*; and
- Clayton Group Services, Inc. September 27, 2002, *Remedial Options Report, Southeast Chicago Cluster Site*.

Since 1998, a total of 123 surface soil samples and 19 subsurface soil samples have been collected and submitted for various analyses. Additionally, a total of 145 test pit excavations have been performed with a minimum of two soil samples collected from each pit.

In addition to the soil and test pit investigations, groundwater was also investigated by E & E. A total of 18 groundwater monitoring wells were sampled for VOCs, SVOCs, and metals. Based on the detected contaminant concentrations, iron, manganese, benzene, and benzo(a)pyrene exceeded the human health threshold for drinking water. Groundwater contamination for these contaminants of potential concern (COPCs) extends across most of the site with the two areas of highest contamination being located on the Alburn site in an area between the Paxton I Landfill and Big Marsh. Additionally, within the Paxton I area, a



significant tetrachloroethene and trichloroethene plume was identified. While this information shows that groundwater has been adversely affected by previous site use, groundwater will be addressed under a separate action and will not be further discussed in this FFS.

1.3.1 Surface and Subsurface Soil Sampling Results

Between August 1998 and June 1999, and under contract to the EPA, E & E's Superfund Technical Assessment and Response Team (START) collected surface and subsurface soil samples and provided for laboratory analysis of approximately 135 compounds. Based on the detected concentrations in these samples, the following COPCs were identified:

- Metals – Arsenic, barium, chromium, lead, and mercury;
- PCBs and Pesticides – Aroclor 1254, beta-BHC, and Dieldrin;
- Volatile organic compounds (VOCs) – Naphthalene; and
- Polynuclear aromatic hydrocarbons (PAHs) - Benzo(a)pyrene, benzo(a)anthracene, and dibenz(a,h)anthracene.

The area of the former Alburn incinerator was the most consistently contaminated parcel of the LCC site. Two other areas that consistently showed contamination were the southwestern area of the Unnamed Parcel and the area immediately south of the Alburn parcel.

For metals, arsenic was the most frequently detected analyte that exceeded human health risk criteria. Barium, chromium, lead, and mercury were detected at concentrations that most frequently exceeded ecological risk criteria. Tables 1-1, 1-2, and 1-3 provide a summary of the analytical results.

1.3.2 Sediment and Surface Water Sampling Results

In addition to surface and subsurface soil sampling, E & E's START collected sediment and surface water samples from the LCC site and Indian Ridge Marsh for laboratory analysis. Based on the detected contaminant concentrations, the following sediment and surface water COPCs were identified:

Sediment:

- Metals –Arsenic, barium, cadmium, chromium, lead, manganese, mercury, and nickel; and
- PAHs –Anthracene, benzo(a)anthracene, benzo(a)pyrene, and chrysene.

Surface Water:

- Metals –Barium, iron, lead, and manganese; and
- Pesticides –Heptachlor and 4, 4'-DDD



The most highly contaminated sediment samples collected at the LCC site were collected from the Alburn area. Toxicity characteristic leaching procedure (TCLP) analysis was also performed for metals. No detectable TCLP concentrations were reported for any analyte. Table 1-4 provides a summary of the analytical results for the COPCs.

In all of the collected samples, barium concentrations were detected at concentrations above the threshold screening value of 0.004 milligrams per liter. As with the sediment sample results, the most contaminated surface water samples were collected in the vicinity of the Alburn parcel. Water quality across the LCC site varies from north to south with the northern section having the highest detected contaminant concentrations and the southeastern section having the lowest detected concentrations. Table 1-5 provides a summary of the analytical results for the COPCs.

1.3.3 Test Pits

In 2000, the Illinois EPA, with assistance from the EPA and the City of Chicago, performed 134 test pit excavations. At each excavation, a minimum of two samples were submitted for laboratory analysis. The first sample in each test pit was collected from a depth of 0.5 to 5 feet below ground surface (BGS), and the second sample was collected in the range of 5 feet to 30 feet BGS. The samples were analyzed for total metals, VOCs, semivolatile organic compounds (SVOCs), pesticides, PCBs, and at certain locations, dioxins.

In 2001, 11 additional test pits were excavated with the samples being submitted for TCLP analysis in addition to the previously listed parameters. A summary of the findings associated with soil analytical data as well as observations about the waste contents is provided below.

Soil Impact

At all of the test pit locations, several contaminants were detected at concentrations exceeding their respective Tiered Approach to Corrective Action Objectives (TACO) Tier 1 Soil Remediation Objectives. Analytical results for the soil samples collected from the test pits indicated a total of 21 VOCs, 23 SVOCs, eight PCBs and pesticides, and six metals at concentrations that exceeded at least one of their TACO Tier 1 criteria. A summary of the contaminants that were detected at concentrations above the Tier 1 criteria is presented in Table 1-6.

Solid Waste

With the exception of one test pit, solid waste was encountered at all of the excavation locations. In general, at each excavation pit with solid waste, there was 1 foot to 3 feet of soil covering the waste material. The excavation depths ranged from 4 feet to 30 feet BGS, and the types of wastes encountered varied greatly, ranging from household waste to syringes to drums labeled trichloro-

ethene. Based on the varying depths of buried waste and the fact that the excavations apparently did not reach the bottom of the waste, the vertical extent of contamination (i.e., total depth/thickness of waste) was not be defined in the previous site investigations.

1.3.4 TCLP Soil Results

As part of the multiple investigations performed at the LCC site, limited TCLP testing was performed on a finite number of samples. As part of the E & E investigation, a total of 68 samples underwent TCLP metals analysis. A total of 3 samples detected lead at a concentration above its TCLP limit. No other metals were detected above their regulatory limits.

During the test pit investigations, 1 soil sample was submitted for TCLP SVOC analysis, 2 soil samples were submitted for TCLP pesticide analysis, 3 soil samples were submitted for TCLP metals analysis, and 4 soil samples were submitted TCLP VOC analysis. In one sample, trichloroethene was detected above its regulatory limit. No other compounds were detected above their regulatory limits in any of the samples.

Since records of waste shipments and disposal locations are not available, it can only be assumed that on-site hazardous waste determination can only be made based on analytical results. While there was limited sampling and analysis for TCLP parameters, based on the analytical results, isolated areas of site soil would be classified as a characteristic hazardous waste.

1.4 Human Health Risk Assessment Summary

This section summarizes the *Human Health Risk Assessment (HHRA) Report for the LCC Site: Alburn, U.S. Drum II, and Unnamed Parcel Areas – Final Report*, previously prepared for the City of Chicago Department of Environment by Montgomery Watson Harza and dated February 2002 (MWH 2002). The complete report is included as Appendix A to this FFS and a summary of the calculated risks is provided in Table 1-7.

1.4.1 Data Evaluation and Selection of Contaminants of Potential Concern

All laboratory-generated analytical data were compiled and used in the risk assessment. Field analytical data, including X-ray fluorescence (XRF) metals data and Geoprobe groundwater samples collected during the Phase I Investigation conducted by E & E (1999a), were considered screening data and were not used. Data were evaluated and COPCs were selected for each area of interest as follows.

1.4.1.1 Soil

Soil data were compared to Illinois TACO background concentrations and Tier 1 Soil Remediation Objectives (ROs) for the receptors listed in Subsection 1.4.2.1 of this report. Chemicals that exceeded both criteria were selected as COPCs.

1.4.1.2 Sediments

Sediment data were compared to Ontario Ministry of the Environment guidelines for protection of aquatic sediment quality (Persaud et al. 1993). Chemicals that exceeded these guideline concentrations were selected as COPCs.

1.4.1.3 Surface Water

Surface water data were compared to ecological and toxicological (EcoTox) thresholds (EPA 1996). Chemicals that exceeded the thresholds were selected as COPCs.

1.4.1.4 Groundwater

Groundwater data were compared to Illinois TACO Class I Groundwater ROs. Chemicals that exceeded these criteria were selected as COPCs.

1.4.1.5 Essential Nutrients

Calcium, potassium, magnesium, iron, and sodium are natural constituents, and were detected in all media. These chemicals are essential human nutrients and EPA has not established maximum allowable daily intakes or reference doses (RfDs) for these chemicals. Therefore, these chemicals were not selected as COPCs.

COPCs selected for soil and sediment for the Alburn, U.S. Drum II, and the Unnamed Parcel of the Lake Calumet Cluster site are listed in Table 1-7 of this FFS report. Approximately 25 to 35 COPCs were identified in each of the areas. A greater number of COPCs were found in soil and groundwater; fewer were found in surface water and sediment. The largest numbers of COPCs were metals or PAHs, but VOCs, SVOCs, pesticides, and PCBs also were represented.

1.4.2 Exposure Assessment

No significant use of the LCC site was occurring when the HHRA was prepared. A possible future use considered by the HHRA was as a solar-powered generating station. Therefore, potential receptors and exposures associated with such a use were used as the basis of the HHRA.

1.4.2.1 Receptors

Five categories of on-site workers were considered:

- A solar panels maintenance worker;
- A mower;
- A landscape maintenance worker;

- A construction worker; and
- A general industrial/commercial maintenance worker.

1.4.2.2 Exposure Pathways

Potential exposure pathways considered for various worker categories included:

- Dermal contact with surface water, groundwater, sediment, and surface and subsurface soils;
- Ingestion and inhalation of contaminants in surface and subsurface soils; and
- Inhalation of volatile groundwater contaminants.

A conceptual site model (CSM) that details which receptor/exposure pathway combinations were judged likely to be complete is included as Figure 3 of the HHRA report.

1.4.2.3 Exposure Point Concentrations

The 95% upper confidence limit (UCL) on the arithmetic average concentrations, assuming a lognormal distribution, was used as the exposure point concentration (EPC) unless the UCL exceeded the maximum detected concentration, in which case the maximum detected concentration was used as the EPC. Ninety-five percent (95%) UCLs were calculated in accordance with EPA guidance (EPA 1992b). When a COPC was reported as not detected in a sample, one-half of the sample quantitation limit was used as a surrogate value.

For groundwater, each well represents a possible exposure point. Therefore, the highest concentration of each COPC in groundwater was used as the EPC.

1.4.2.4 Quantification of Exposure

Exposure estimates were calculated using standard EPA exposure estimation equations. The exposure factor and physical chemical property values used to estimate exposures, along with the sources of the values, are summarized in Tables 4-1 through 4-6 of the HHRA. Most exposure factor and physical chemical values were obtained from EPA or Illinois EPA guidance documents.

1.4.3 Toxicity Assessment

RfDs and cancer slope factors (SFs) for all of the COPCs were compiled from various sources and presented in Table 5-1 of the HHRA report. Most of the values were obtained from EPA's Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables (HEAST). A few values that were not available in IRIS or HEAST were obtained from EPA Region 9's 2001 Preliminary Remediation Goal (PRG) Table, Oak Ridge National Laboratory's (ORNL) Risk Assessment Information System (RAIS), or through personal communications with EPA personnel. The tissues or organs affected by the carcinogenic COPCs are summarized in Table 5-2 of the HHRA report. The

critical noncarcinogenic effects and target organs of the systemic toxicants are summarized in Table 5-3 of the HHRA report.

1.4.4 Risk Characterization

Risk characterization procedures and calculations are described in the Human Health Risk Assessment report (Appendix A) for carcinogens and noncarcinogens. The human health risks estimated for all three areas are summarized in Table 1-7.

1.4.4.1 Alburn Area

Cancer risk and noncancer hazard estimates for the Alburn area are presented in HHRA Table 6-1. Soil COPCs were estimated to pose an excess lifetime cancer risk (ELCR) ranging from 2×10^{-6} for construction and landscape workers to 2×10^{-5} for general industrial/commercial workers. The total estimated hazard indices (HIs) for soil were less than 1 for all workers except construction workers for whom the HI was 3. For groundwater, surface water, and sediment, estimated ELCRs were less than 1×10^{-6} and the total HI was less than 0.1 for all workers.

The estimated ELCRs from soil COPCs fall within the 10^{-4} to 10^{-6} range generally considered acceptable by EPA. The estimated ELCRs for other media were less than 10^{-6} and would be considered minimal and acceptable. The COPCs that contributed significantly to the estimated ELCR included arsenic, benzene, benzo(a)pyrene, PCBs, and vinyl chloride.

The estimated HI of 3 for construction workers exceeds 1, the value below which adverse noncarcinogenic effects would not be expected. An HI above 1 does not necessarily mean that adverse effects would be manifested, but as the value increases above 1 the risk of adverse effects also increases. The elevated noncancer hazard was due primarily to toluene.

1.4.4.2 U.S. Drum II

Cancer risk and noncancer hazard estimates for the U.S. Drum II area are presented in HHRA Table 6-3. Soil COPCs were estimated to pose an ELCR ranging from 5×10^{-6} for construction workers to 5×10^{-5} for general industrial/commercial workers. The total estimated HIs for soil were less than 1 for all workers, although the HI approached 1 (0.9) for construction workers. For groundwater and surface water estimated ELCRs were less than 1×10^{-6} , and the total HI was less than 0.1 for all workers. No COPCs were identified for sediment in this area. The COPCs that contributed significantly to the estimated ELCR included arsenic, benzo(a)pyrene, dibenz(a,h)anthracene, and PCBs.

1.4.4.3 Unnamed Parcel

Cancer risk and noncancer hazard estimates for the Unnamed Parcel are presented in HHRA Table 6-5. Soil COPCs were estimated to pose an ELCR ranging from



1×10^{-6} for construction and landscape workers to 2×10^{-5} for general industrial/commercial workers. The total estimated HIs for soil were less than 1 for all workers. For groundwater, estimated ELCRs were less than 1×10^{-6} , and the total HI was less than 0.001 for all workers. No COPCs were identified for surface water or sediment in this area. The COPCs that contributed significantly to the estimated ELCR included arsenic and benzo(a)pyrene.

1.4.5 Uncertainties

There are a number of uncertainties that affect all aspects of the risk assessment process. Specific areas of uncertainty are related to data evaluation, exposure assessment, toxicity assessment, and risk characterization. Various uncertainties are identified that affect each of these areas. Most uncertainties arise from conservative (health-protective) assumptions or procedures. Therefore, the cumulative effect of all of the uncertainties is that risks are more likely to be overestimated than underestimated.

1.4.6 Conclusions

The conclusions of the HHRA report reiterate the risk characterization findings.

The estimated ELCRs in all three areas are within or less than the 10^{-4} to 10^{-6} range generally considered acceptable by EPA. Remedial action is usually not required for risks in this range; however, this general rule is subject to modification based on site-specific factors.

The estimated HI of 3 for construction workers in the Alburn area exceeds 1, the value below which adverse noncarcinogenic effects would not be expected. An HI above 1 does not necessarily mean that adverse effects would be expected, but as the value increases above 1 the risk of adverse effects also increases. The elevated noncancer hazard was due primarily to toluene. The oral RfD for toluene includes an uncertainty factor of 1,000 and the inhalation reference concentration (RfC) includes an uncertainty factor of 300. Given the magnitude of these uncertainty, or "safety" factors, coupled with the conservative exposure assumptions used, construction workers are probably not likely to experience adverse noncancer effects from exposure to toluene at a level that gives an estimated HI of 3.

An important limitation of the HHRA report is that it only considers worker exposure. Workers, as a group, are generally adults and are generally healthy. Therefore, they may be less sensitive to potential adverse effects of exposure to environmental toxicants than other segments of the population such as the young, the old, and the infirm. If the site is ultimately used for a purpose such as a recreational or general commercial facility, exposure of more sensitive segments of the population could become a significant concern.

1.5 Habitat-Based Risk Evaluation

A baseline ecological risk assessment (BERA) was prepared by the EPA Environmental Response Team (ERT 2001) for the LCC site, which followed guidance issued by the EPA. The complete BERA is presented in Appendix B of this report. The BERA was conducted as a follow-up to a screening-level ecological risk assessment (SLERA) for the site, which identified over 100 COPCs, including metals, VOCs, SVOCs, PAHs, pesticides, and PCBs.

Assessment endpoints are explicit expressions of the actual ecological resources that are to be protected. Ecological resources include those without which ecosystem function would be significantly impaired, or those providing critical components (i.e., habitats). A review of the habitat of the LCC site and its associated wetlands provided information for the selection of assessment endpoints. In general, endpoints are aimed at the viability of terrestrial and aquatic populations.

The BERA evaluated risk to the following assessment endpoints:

1. Wetland structure and function;
2. Fish recruitment and nursery function;
3. Benthic community viability and function;
4. Amphibian population viability and function;
5. Insectivorous bird viability and recruitment;
6. Omnivorous waterfowl viability and recruitment;
7. Herbivorous bird viability and recruitment;
8. Piscivorous bird viability;
9. Omnivorous mammal viability;
10. Carnivorous mammal viability;
11. Soil-invertebrate community function; and
12. Plant community viability.

Field sampling to support the BERA was conducted in 2001 and included: (1) collecting water, sediment, soil, fish, and crayfish for chemical analysis; (2) collecting water and sediment for toxicity testing with laboratory-reared fish (*Pimephales promelas*, fathead minnow) and benthic invertebrates (*Hyaella azteca*, amphipod), respectively; and (3) collecting soil for toxicity and bioaccumulation testing with earthworms (*Eisenia foetida*) and ryegrass (*Lolium perenne*).

For assessment endpoints 1, 2, 3, 11, and 12, multiple measures of exposure and effects were evaluated and a weight-of-evidence approach was used to infer the presence or absence of risk. For endpoints 4 to 10, which pertain to wildlife, a food-chain exposure model was used to estimate a daily chemical dose from food for comparison with toxicity reference values from the literature. Nearly all

assessment endpoints were found to be at risk. A summary of the individual assessment endpoint findings is provided below:

1. Wetland structure and function were predicted to be at risk based on adverse effects on fish, benthos, and nearly all wildlife functional groups from a variety of chemicals in water, sediment, and biota.
2. Fish recruitment and nursery function were predicted to be at risk for two reasons: (1) reduced survival of fathead minnows in toxicity tests with surface water from pond LHL-1 and the southeast ponds, and (2) exceedances of surface water screening criteria for metals (aluminum, chromium, copper, lead, vanadium, and zinc) and PCBs in the southeast ponds.
3. Benthic community viability and function were predicted to be at risk for three reasons: (1) low diversity and abundance of benthos in on-site ponds and nearby wetlands, (2) reduced survival of amphipods in toxicity tests with sediment from pond LHL-1 and the southeast ponds, and (3) exceedances of sediment benchmarks for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc), DDT breakdown products, and PCBs in sediment from on-site ponds.
4. Amphibian populations were predicted to be at risk based on reduced survival of amphipods in toxicity tests with sediment from pond LHL-1 and the southeast ponds. Amphipods were considered to be a suitable surrogate for amphibians because both amphipods and amphibians have intimate contact with sediment in ponds and wetlands.
5. Insectivorous bird viability and recruitment were predicted to be at risk from PCBs, aluminum, cadmium, chromium, copper, lead, mercury, selenium, and zinc based on food-chain modeling.
6. Omnivorous waterfowl were predicted to be at risk from PCBs and selenium based on food-chain modeling.
7. *Herbivorous bird viability and recruitment could not be evaluated due to insufficient data.* The plan for evaluating herbivorous birds was to grow ryegrass in soil samples from the site, analyze the ryegrass for chemicals of concern, and use the resulting data as input for a food-chain exposure model. However, because of poor growth of ryegrass in site soil, there was insufficient plant biomass for chemical analysis.
8. Piscivorous bird viability was predicted to be at risk from PCBs and selenium and perhaps also from chromium and lead based on food-chain modeling.
9. Omnivorous mammal viability was predicted to be at risk from PCBs, numerous SVOCs, antimony, and barium based on food-chain modeling.
10. Carnivorous mammal viability was predicted to be at risk from PCBs and numerous metals (aluminum, arsenic, antimony, barium, cadmium, iron, lead, mercury, selenium, vanadium, and zinc) based on food-chain modeling.
11. The soil-invertebrate community at the site was predicted to be at risk for two reasons: (1) reduced survival of earthworms in toxicity tests with site



soil samples from some sampling locations, and (2) exceedances of soil screening levels for chromium, iron, and lead at all sampling locations and for SVOCs at selected locations.

12. Plant community viability was predicted to be at risk for two reasons: (1) reduced ryegrass survival, shoot length and weight, and root length and weight in toxicity tests with site soil samples, and (2) exceedances of one or more soil screening benchmarks for metals (aluminum, chromium, lead, and silver) and pesticides (Aldrin, DDD, DDE, and chlordane) at most sampling locations.

The BERA concludes that there is a risk to the aquatic and terrestrial communities at and in the vicinity of the LCC site. The calculated risks used only contaminant exposure from food sources. Contaminant concentrations in water, sediment, and soil were excluded from the calculations. Therefore, the risk to receptor organisms living on the site is likely underestimated, and there is likely risk to off-site communities preying on organisms that use the site.

**Table 1-1 Summary of Surface Soil Analytical Results for Contaminants of Potential Concern
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois**

Compound	Frequency of Detection	Minimum Detection	Average Detection	Maximum Detection	Region 3 Human Health RBC ^a	Number of Samples Exceeding RBC	RCRA EDQL ^b	Number of Samples Exceeding RCRA EDQL
Metals (micrograms per kilogram)								
Arsenic	83/120	0.800	7.761	26	4	74/120	5.700	59/120
Barium	120/120	21.300	143.388	1,200	14,000	0/120	1.040	120/120
Chromium	120/120	9.550	244.963	2,200	NP	NP	0.400	120/120
Lead	112/120	10.700	185.862	1,170	NP	NP	0.451	112/120
Mercury	116/120	0.012	0.364	13	61	0/120	0.008	116/120
Volatile Organic Compounds (milligrams per kilogram)								
Naphthalene	66/121	0.022	0.888	41	41000	0/121	0.10	39/121
Semivolatile Organic Compounds (milligrams per kilogram)								
Benzo(a)pyrene	112/121	0.034	1.035	6.8	0.78	45/121	1.52	23/121
Benzo(a)anthracene	116/121	0.029	1.022	9	7.8	1/121	5.21	3/121
Dibenz(a,h)anthracene	99/121	0.038	0.341	2.2	0.78	11/121	18.4	0/121
PCBs/Pesticides (milligrams per kilogram)								
Aroclor 1254	68/120	0.007	1.484	68.8	2.9	2/120	NP	NP
beta-BHC	58/120	0.001	0.009	0.075	3.2	0/120	0.004	33/120
Dieldrin	61/120	0.001	0.056	1.8	0.36	3/120	0.002	37/120

Note: Data summarized from *The Nature and Extent of Contamination at the Lake Calumet Site* (E & E 1999b).

Key

RBC = Risk-based concentration.

NP = Information not provided or calculated.

Source:

^a EPA Region 3 human health risk-based screening concentrations for soil for commercial or industrial use (October 1998).

^b EPA Region 5 Resource Conservation and Recovery Act Division's Ecological Data Quality Levels (April 1998).

Table 1-2 Summary of Surface Soil Analytical Results (2 to 3 Feet Below Ground Surface) for Contaminants of Potential Concern
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois

Compound	Frequency of Detection	Minimum Detection	Average Detection	Maximum Detection	Region 3 Human Health RBC ^a	Number of Samples Exceeding RBC	Number of Samples Exceeding	
							RCRA EDQL ^b	RCRA EDQL
Metals (micrograms per kilogram)								
Arsenic	3/15	8.8000	35.967	63.5	3.8	3/15	5.70	3/15
Barium	15/15	40.500	117.913	266	14,000	0/15	1.04	15/15
Chromium	15/15	13.400	172.127	1,260	NP	NP	0.4	15/15
Lead	15/15	23.000	280.087	812	NP	NP	0.45	15/15
Mercury	14/15	0.046	5.496	73.5	1610	1/15	0.008	14/15
Volatile Organic Compounds (milligrams per kilogram)								
Naphthalene	14/15	0.036	9.657	90	4,100	0/15	0.10	10/15
Semivolatile Organic Compounds (milligrams per kilogram)								
Benzo(a)pyrene	15/15	0.071	1.002	4.8	0.78	6/15	1.52	3/15
Benzo(a)anthracene	15/15	0.079	0.986	4.6	7.8	0/15	5.21	0/15
Dibenz(a,h)anthracene	14/15	0.033	0.337	1.8	0.78	1/15	18.4	0/15
PCBs/Pesticides (milligrams per kilogram)								
Aroclor 1254	6/16	0.016	1.281	2.972	2.9	1/16	NP	NP
beta-BHC	2/16	0.017	0.018	0.018	3.20	0/16	0.004	2/6
Dieldrin	10/16	0.027	0.106	0.420	0.36	1/16	0.002	10/16

Note: Data summarized from *The Nature and Extent of Contamination at the Lake Calumet Cluster Site* (E & E 1999b).

Key:

RBC = Risk-based concentration.

FoE = Frequency of exceedance.

NP = Information not provided or calculated.

Source:

^a U.S. EPA Region 3 human health risk-based screening concentrations for soil for commercial or industrial use (October 1998).

^b U.S. EPA Region 5 Resource Conservation and Recovery Act Division's Ecological Data Quality Levels (April 1998).

Table 1-3 Summary of Subsurface Soil Analytical Results (4 to 6 Feet Below Ground Surface) for Contaminants of Potential Concern
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois

Compound	Frequency of Detection	Minimum Detection	Average Detection	Maximum Detection	Region 3 Human Health RBC ^a	Number of Samples Exceeding RBC	Number of Samples Exceeding	
							RCRA EDQL ^b	RCRA EDQL
Metals (micrograms per kilogram)								
Arsenic	1/15	17.100	17.100	17.100	3.8	1/15	5.70	1/15
Barium	15/15	16.800	107.087	275.000	14,000	0/15	1.04	15/15
Chromium	15/15	3.960	51.017	336.000	NP	NP	0.4	15/15
Lead	15/15	7.730	427.062	2,950.000	NP	NP	0.45	15/15
Mercury	13/15	0.029	0.645	3.820	610	0/15	0.008	13/15
Volatile Organic Compounds (milligrams per kilogram)								
Naphthalene	14/14	0.250	9.020	44.000	4,100	0/14	0.10	14/14
Semivolatile Organic Compounds (milligrams per kilogram)								
Benzo(a)pyrene	13/14	0.070	2.354	11.000	0.78	8/14	1.52	5/14
Benzo(a)anthracene	14/14	0.060	2.149	12.000	7.80	1/14	5.21	1/14
Dibenz(a,h)anthracene	12/14	0.029	0.752	2.000	0.78	4/14	18.4	0/14
PCBs/Pesticides (milligrams per kilogram)								
Aroclor 1254	5/14	0.263	1.299	3.552	2.90	1/14	NP	NP
beta-BHC	5/14	0.007	0.087	0.380	3.2	0/14	0.004	5/14
Dieldrin	9/14	0.005	0.051	0.160	0.36	0/14	0.002	9/14

Note: Data summarized from *The Nature and Extent of Contamination at the Lake Calumet Cluster Site* (E & E 1999).

Key RBC = Risk-based concentration.
NP = Information not provided or calculated.

Source:

^a U.S. EPA Region 3 human health risk-based screening concentrations for soil for commercial or industrial use (October 1998).

^b U.S. EPA Region 5 Resource Conservation and Recovery Act Division's Ecological Data Quality Levels (April 1998).

**Table 1-4 Summary of Sediment Sample Analytical Results for Contaminants of Potential Concern
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois**

Compound	Frequency of Detection	Minimum Detection	Average Detection	Maximum Detection	RCRA EDQL ^a	Number of Samples Exceeding RCRA EDQL
Metals (milligrams per kilogram)						
Arsenic	26/27	4.900	17.015	104	5.9	24/27
Barium	27/27	42.400	156.822	582	NP	NP
Cadmium	24/27	0.200	2.813	8.9	0.596	21/27
Chromium	27/27	20.000	96.737	537	26	26/27
Lead	27/27	23.500	184.374	725	31	26/27
Manganese	20/20	419.000	915.850	1,670	NP	NP
Mercury	13/27	0.098	0.369	0.90	0.174	11/27
Nickel	20/20	24.3	35.385	49.4	16	20/20
Semivolatile Organics (milligrams per kilogram)						
Anthracene	26/27	0.190	0.557	1.3	0.03	26/27
Benzo(a)pyrene	26/27	0.160	0.611	1.5	0.03	26/27
Benzo(a)anthracene	26/27	0.190	0.557	1.3	0.03	26/27
Chrysene	26/27	0.230	0.688	1.7	0.06	26/27

Note: Data summarized from *The Nature and Extent of Contamination at the Lake Calumet Cluster Site* (E & E 1999b).

Key:

NP = Information not provided or calculated.

Source:

^a EPA Region 5 Resource Conservation and Recovery Act Division's Ecological Data Quality Levels (April 1998).

**Table 1-5 Summary of Surface Water Sample Analytical Results for Contaminants of Potential Concern
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois**

Compound	Frequency of Detection	Minimum Detection	Average Detection	Maximum Detection	OSWER ^a EcoTox	Number of Samples Exceeding	
						OSWER Ecotox	RCRA ^b EDQL
Metals (milligrams per kilogram)							
Barium, dissolved	4/4	0.036	0.148	0.285	0.004	4/4	5
Barium, total	25/25	0.049	0.108	0.358	0.004	25/25	5
Iron, dissolved	4/4	0.054	0.195	0.523	1	0/4	NP
Iron, total	25/25	0.084	0.909	6.580	1	7/25	NP
Lead, total	7/25	0.003	0.022	0.107	0.002	7/25	7/25
Manganese, dissolved	4/4	34.7	56.000	75.8	NP	NP	NP
Manganese, total	25/25	35.3	52.004	73.9	NP	NP	NP
Pesticides (milligrams per kilogram)							
4,4' -DDD	2/25	0.00001	0.00002	0.00003	NP	NP	1.1E-6
Heptachlor	3/25	0.00001	0.0001	0.0003	6.9E-6	3/25	3.9E-7

Note: Data summarized from *The Nature and Extent of Contamination at the Lake Calumet Cluster Site* (E & E 1996b).

Key: NP = Information not provided or calculated.

Source:

^a EPA Region 5 Resource Conservation and Recovery Act Division's Ecological Data Quality Levels (April 1998).

^b EPA Office of Solid Waste and Emergency Response ecological and toxicological thresholds (January 1996).

**Table 1-6 Comparison of Test Pit Soil Analytical Data to TACO Cleanup Objectives
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois**

Parcel		Alburn Incinerator			U.S. Drum II			Unnamed Parcel		
Compound		Maximum Detected Concentration			Maximum Detected Concentration			Maximum Detected Concentration		
		a	b	c	a	b	c	a	b	c
Inorganics (milligrams per kilogram)										
Antimony	1,020	X		X		X		X		Not Detected
Arsenic	151	X		X		X		X		99.9
Beryllium	8.4	X		X		X		X		3.0
Chromium (Total)	1,730	X		X		X		X		1,620
Lead	6,730	X		X		X		X		5,710
Manganese	40,500	X		X		X		X		13,000
Volatile Organic Compounds (milligrams per kilogram)										
1,1,1-Trichloroethane	ND					ND				52,000
1,1-Dichloroethane	ND					ND				440
1,2-Dibromo-3-chloropropane	ND					ND				470
1,2-Dichloroethane	ND					14	X	X		720
Benzene	92		X	X		20	X	X		ND
Carbon disulfide	14		X	X		ND				ND
Chlorobenzene	47		X	X		120	X	X		180
Chloroform	ND					6	X	X		ND
Ethylbenzene	5,000		X	X		260	X	X		1,800
Methylene chloride	400		X	X		ND				470
Tetrachloroethene	360		X	X		28	X	X		ND
Toluene	3,700		X	X		730	X	X		8,900
Trichloroethene	370		X	X		ND				460
Vinyl chloride	0.26		X	X		0.23	X	X		ND
Xylenes	25,000		X	X		950	X	X		56,000
Semivolatile Organic Compounds (milligrams per kilogram)										
Benzo(a)anthracene	67	X		X		100	X	X		310
Benzo(a)pyrene	37	X		X		55	X	X		250
Benzo(b)fluoranthene	72	X		X		71	X	X		350
Benzo(k)fluoranthene	ND					ND				150

1. Introduction

Focused Feasibility Study Section No.: 1

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**Table 1-6 Comparison of Test Pit Soil Analytical Data to TACO Cleanup Objectives
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois**

Parcel	Alburt Incinerator			U.S. Drum II			Unnamed Parcel					
	Maximum Detected Concentration	a	b	c	Maximum Detected Concentration	a	b	c	Maximum Detected Concentration	a	b	c
bis(2-Chloroethyl) Ether	0.68	X		X	ND				ND			
bis(2-Ethylhexyl) phthalate	ND				480	X			ND			
Dibenz(a,h)anthracene	11	X		X	9.1	X			59	X		X
Indeno(1,2,3-cd)pyrene	24	X		X	22	X			140	X		X
Pesticides/Herbicides (milligrams per kilogram)												
alpha-BHC	ND				ND				1.7	X		X
Heptachlor	ND				ND				2.8	X		X

Note: Data summarized from *Comprehensive Site Investigation Report, Lake Calumet Cluster Site: Alburt, U.S. Drum, and Unnamed Parcel Areas* (Harza Engineering Company, May 2001).

^a TACO Tier 1 Soil Remediation Objective for Industrial-Commercial Ingestion Exposure Route.

^b TACO Tier 1 Soil Remediation Objective for Industrial-Commercial Inhalation Route.

^c TACO Tier 1 Soil Remediation Objective for the Soil Component of the Class I Groundwater Ingestion Exposure Route.

Key:

TACO = Tiered Approach to Corrective Action Objectives.

ND = Not detected at a concentration above the TACO Industrial-Commercial Ingestion or Exposure Route Objective.

X = Exceeds Soil Remediation Objective for exposure pathway indicated.

Table 1-7 Summary of Human Health Risk Estimates

Environmental Medium	On-Site Worker	Construction Worker	Industrial/Commercial Worker	Mower	Landscape Worker	Risk Drivers	
Alburn Area							
Total Excess Lifetime Cancer Risks							
Soil	5E-6	2E-6	2E-5	1E-5	2E-6	Arsenic, benzene, benzo(a)pyrene, total PCBs, vinyl chloride	
Groundwater	8E-7	3E-8	8E-7	NA	NA		
Surface Water	3E-9	1E-10	3E-9	NA	NA		
Sediment	2E-7	9E-9	2E-7	NA	NA		
Total Noncancer Hazard Index							
Soil	2E-2	3E+0	2E-1	4E-2	8E-1	Toluene	
Groundwater	1E-2	1E-1	1E-2	NA	NA		
Surface Water	4E-5	4E-4	4E-5	NA	NA		
Sediment	1E-3	1E-2	1E-3	NA	NA		
U.S. Drum Area							
Total Excess Lifetime Cancer Risks							
Soil	1E-5	3E-6	5E-5	3E-5	4E-6	Arsenic, benzo(a)pyrene, dibenz(a,h)anthracene, total PCBs	
Groundwater	4E-7	1E-8	4E-7	NA	NA		
Surface Water	9E-10	4E-11	9E-10	NA	NA		
Total Noncancer Hazard Index							
Soil	1E-2	9E-1	6E-2	3E-2	2E-1	None	
Groundwater	3E-3	4E-2	5E-4	NA	NA		
Surface Water	2E-5	3E-4	4E-6	NA	NA		
Unnamed Parcel							
Total Excess Lifetime Cancer Risks							
Soil	3E-6	1E-6	2E-5	1E-5	1E-6	Arsenic, benzo(a)pyrene	
Groundwater	2E-7	9E-9	2E-7	NA	NA		
Total Noncancer Hazard Index							
Soil	1E-2	6E-1	5E-2	2E-2	1E-1		None
Groundwater	4E-4	4E-3	4E-4	NA	NA		



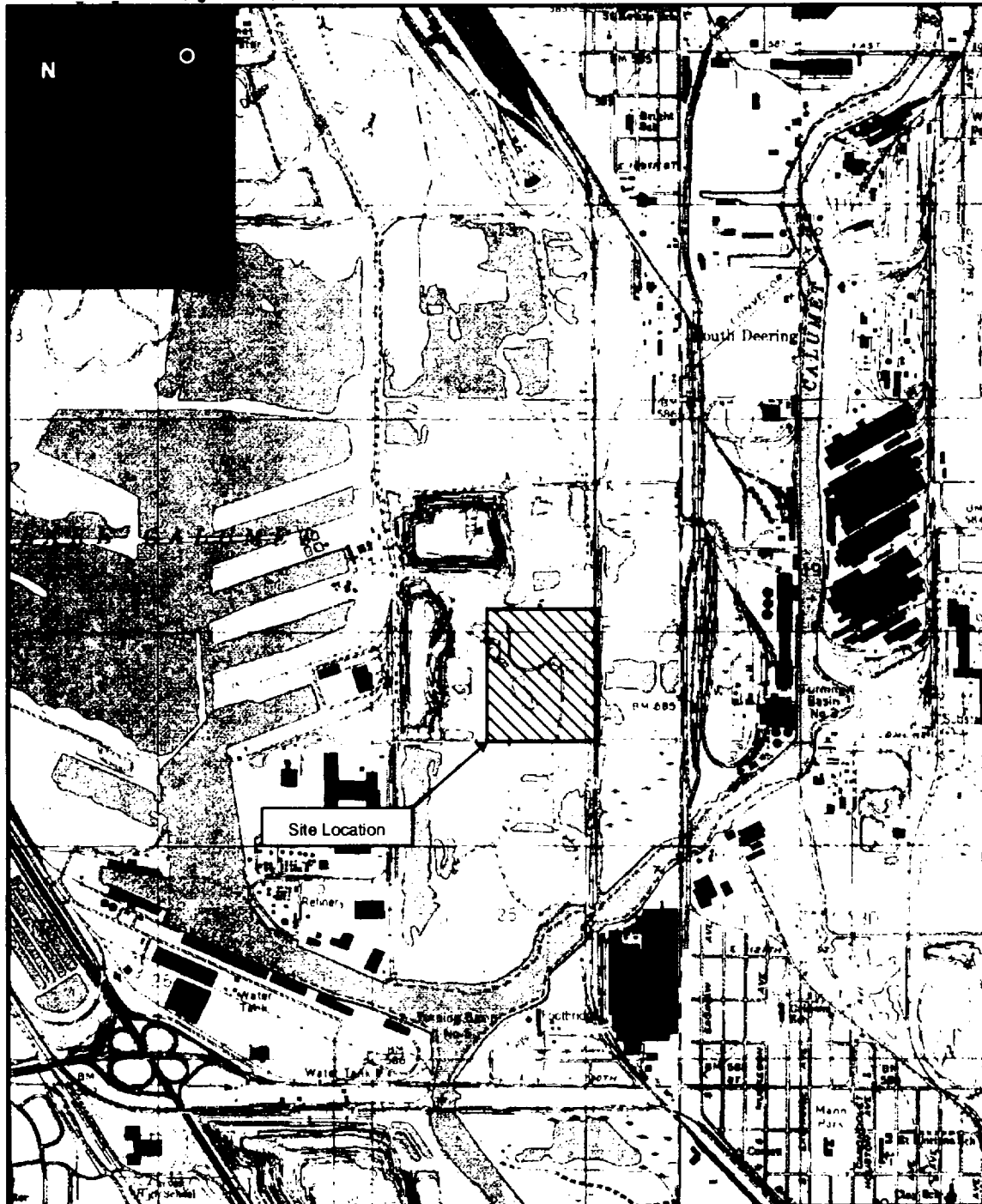
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SOURCE: USGS 7.5 Minute Quadrangle Map, Lake Calumet, Illinois

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APPROXIMATE SCALE

0 1/2 1 Mile

Figure 1-1

**SITE LOCATION MAP
LAKE CALUMET CLUSTER SITE
CHICAGO, ILLINOIS**

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**Figure 1-2 AERIAL SITE VIEW
LAKE CALUMET CLUSTER SITE
CHICAGO, ILLINOIS**

SOURCE: Ecology and Environment, Inc., 2006.

2

Identification and Screening of Technologies

2.1 Introduction

This section presents the first phase of the FFS process for the Lake Calumet Cluster site. The first step in developing remedial alternatives is to establish remedial action objectives (RAOs). Thus, for each medium of interest at the site, RAOs that will protect both human health and the environment are established. These objectives are typically based on COPCs and contaminants of potential ecological concern (CPECs), applicable or relevant and appropriate requirements (ARARs), and the findings of the human health and ecological risk evaluations. General response actions describing measures that will satisfy the remedial action objectives are then developed. This includes estimating the areas or volumes to which the response actions may be applied. Finally, remedial technologies applicable to each action are identified and discussed with respect to their effectiveness and implementability. The applicable technologies are then assembled into medium-specific remedial alternatives in Section 3.

2.2 Remedial Action Objectives

2.2.1 Development of Remedial Action Objectives

Based on the Human Health Risk Evaluation, Ecological Risk Evaluation, and potentially complete exposure pathways, the following list of RAOs was developed for protection of human health and the environment:

1. Prevent direct and dermal contact with, and ingestion of, contaminated soil/landfill contents;
2. Prevent inhalation of dust;
3. Minimize or eliminate contaminant leaching to groundwater aquifers;
4. Prevent ingestion, adsorption, and bioconcentration of on-site surface water and sediment;
5. Provide groundwater monitoring of the contaminant plume;
6. Prevent explosions from accumulations of LFG; and
7. Prevent inhalation of COPCs present in the LFG in excess of benchmark concentrations.

Selected RAOs are consistent with those presented in *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites* (EPA/540/P-91/001). Groundwater remedies and development of groundwater RAOs are not included as part of this FFS.

2.2.2 ARARs and Other Policies and Guidance "To Be Considered"

Prior to implementing a remedial action, the federal, state, and local regulatory requirements that may be pertinent to such an action must be identified. Such requirements may guide or impact the selection of a remedial approach. In the course of conducting the FFS for the LCC site, EEI identified ARARs as well as other "To Be Considered" criteria (TBCs) from policy or guidance documents that may be pertinent to evaluating and implementing remedial options.

Requirements typically fall into three categories: chemical-specific, location-specific, and action-specific ARARs. Chemical-specific ARARs set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances. During the planning process, these requirements are used to establish site cleanup levels or to provide a basis for calculating cleanup levels for the media of interest. They are also used to define an acceptable level of discharge, for sites where discharge is necessary, which will determine the treatment and disposal requirements, and to assess the effectiveness of the remedial alternatives. During implementation of a remedial action, chemical-specific ARARs are used to define acceptable exposure levels.

Location-specific requirements set restrictions on the types of remedial activities that can be performed based on site-specific characteristics or location. Alternative remedial actions may be restricted or precluded based on Federal and State siting laws for hazardous waste facilities, proximity to wetlands or floodplains, or proximity to manmade features such as existing landfills, disposal areas, and historic buildings.

Action-specific requirements are triggered by the particular remedial activities that are selected to accomplish the cleanup. After remedial alternatives are developed, action-specific ARARs that specify performance levels, actions, or technologies, as well as specific levels for discharge of residual chemicals, provide a basis for assessing the feasibility and effectiveness of the remedies.

2.2.2.1 Chemical-Specific ARARs and TBCs

A list of potential chemical-specific ARARs and TBCs for the LCC site are provided in Table 2-1, accompanied by a brief discussion of applicability to the site. For the LCC site, the anticipated interim remedial actions may include consolidation of waste and capping. For areas where waste will be removed, chemical-specific ARARs would include those that pertain to cleanup goals to determine that sufficient material has been removed and remaining soils do not

pose significant risks to the environment. Chemical-specific ARARs for the LCC site also include solid waste management regulations, Clean Water Act regulations, air regulations for flaring of landfill gas, and the Toxic Substances Control Act for establishing PCB cleanup goals. Those ARARs are summarized in Table 2-1.

2.2.2.2 Location-Specific ARARs and TBCs

A list of potential location-specific ARARs and TBCs for the LCC site is provided in Table 2-2. Location-specific ARARs include the Federal Endangered Species Act, as well as State of Illinois surface water, floodplain, and wetlands requirements.

The Federal Endangered Species Act (ESA) requires action to avoid jeopardizing the continued existence of listed threatened and endangered (T&E) species, or destroying or adversely modifying critical habitat. The ESA requires federal agencies to consult or confer with other agencies such as the U.S. Fish and Wildlife Service (FWS), the National Oceanic and Atmospheric Administration (NOAA), and the National Marine Fisheries Service. State requirements also require consultation with the Illinois Department of Natural Resources. Although no T&E species have been identified at the site, there are T&E species in nearby water bodies, and any remedial action taken at the LCC site must minimize any negative impacts to those habitats from site activities.

Section 303.441 of Title 35 of the Illinois Administrative Code (IAC) designates the Little Calumet River, the Grand Calumet River, and Lake Calumet as secondary contact and indigenous aquatic life waters (as opposed to drinking water sources). Therefore, the water quality standards that apply to these water bodies are specified in Part 302 Subpart D, including standards for pH, dissolved oxygen, chemical constituents, and toxic substances. These requirements may be applicable to wastewater discharges generated in the course of the remedial action.

The site is located adjacent to wetland areas, and the Illinois wetland ARARs typically apply to the siting of new facilities. However, based on reviews of the Federal Emergency Management Association's National Flood Insurance Program Flood Insurance Rate Map, the LCC site does not lie within the boundaries of the 100-year floodplain. Therefore, the LCC site is not subject to 35 IAC 703.184, 724.118, 811.102, and 811.302, and these codes are not considered as ARARs for the site.

2.2.2.3 Action-Specific ARARs and TBCs

A list of potential action-specific ARARs and TBCs for the LCC site is provided in Table 2-3. Action-specific ARARs include final cover requirements, U.S. Department of Transportation (DOT) shipping regulations, Occupational Safety

and Health Administration (OSHA) regulations, NPDES requirements (40 CFR 122), Discharge of Stormwater Runoff (40 CFR 122.26), and RCRA Subtitle C requirements for hazardous waste landfills (e.g., requires cap permeability of 10^{-7} centimeters per second [cm/sec]). Title 35, Illinois Administrative Code, Part 212, Subpart K is relevant and appropriate for control of air emissions (fugitive particulate and visible emission standards for excavation of soil and staging in piles), and requires that standards of care be used during implementation (e.g., control of fugitive dust through spraying of water).

Chapter 11-4 of the Municipal Code of the City of Chicago pertains to Environmental Protection and Control. Specific sections regarding waste management, hazardous waste management, visible air emissions, and noise are “to be considered” for the planned remedial actions. Landfill operations require a city permit; waste handling and the disposal of wastes generated in the course of a remedial action must comply with waste management requirements. Likewise, air emissions, including visible emissions, must be controlled during the remedial action. Municipal codes also restrict noise levels and hours of operation for heavy equipment.

Illinois Pollution Control Board Cover Requirements

The state of Illinois has three distinct sets of requirements for the design of cover systems for landfills. They are 35 IAC 811, 817, and 724. Major components of each cover system are described below.

35 IAC 811

Title 35 IAC 811 contains the standards for all new landfills, with Subpart C containing standards for landfills receiving chemical and putrescible wastes. Subpart C also contains the requirements for the final cover.

Under 35 IAC 811.314 (Final Cover System), the landfill must be covered by a final cover consisting of a low-permeability layer overlain by a final protective layer.

The technical standards for the low-permeability layer are:

- The low-permeability layer must cover the entire unit and connect with the liner system.
- The low-permeability layer must consist of one of the following:
 1. A compacted earth layer constructed to a minimum allowable thickness of 3 feet, and the layer must be compacted to achieve a permeability of 1×10^{-7} cm/sec and must minimize void spaces.



2. A geomembrane, which must provide performance equal or superior to the compacted earth layer described above. The geomembrane must have the strength to withstand the normal stresses imposed by the waste stabilization process and be placed over a prepared base free from sharp objects and other materials that may cause damage.
3. Any other low-permeability layer construction techniques or materials, provided that they provide equivalent or superior performance to the requirements of the earthen system.

The technical standards for the final protective layer are:

- The final protective layer must cover the entire low-permeability layer.
- The thickness of the final protective layer must be sufficient to protect the low-permeability layer from freezing and minimize root penetration of the low-permeability layer, but must not be less than 3 feet.
- The final protective layer must consist of soil material capable of supporting vegetation.
- The final protective layer must be placed as soon as possible after placement of the low-permeability layer to prevent desiccation, cracking, freezing, or other damage to the low-permeability layer.

Finally, the cover must be protective of human health and the environment.

While the LCC site is not a new landfill, various sections of the site have received chemical wastes in addition to municipal wastes. Therefore, 35 IAC 811 has been included as an ARAR.

35 IAC 817

Title 35 IAC 817 contains the standards that apply exclusively to the non-putrescible wastes produced by the steel and foundry processes covered by various Standard Industrial Classification (SIC) Codes.

The State of Illinois may approve the use of iron- and steel-making slags and foundry sands for land reclamation purposes upon a demonstration by the owner or operator that such use will not cause an exceedance of the applicable groundwater quality standards specified in 35 IAC 620.

Under 35 IAC 817, there are two standards for a final cover. The first (35 IAC 817.303) is for steel slags and sands, which may have a reuse value, and the second (35 IAC 817.410) is for low-risk wastes. For the purposes of this FFS, the more stringent cover design (35 IAC 817.410) will be used.

The requirements set forth under 35 IAC 817.410 are same as those set forth under 35 IAC 811.314 with the following exceptions:

- The low-permeability layer, if constructed of earthen material, shall be a minimum of 2 feet thick.
- The protective layer shall have a minimum thickness of 1.5 feet.

Given that slag may be imported from local steel mills to be used as part of a gas collection system, the requirements of 35 IAC 817 are considered to be relevant.

35 IAC 724

This standard is for owners and operators of hazardous waste treatment, storage, and disposal facilities. Its purpose to establish minimum standards that define the acceptable management of hazardous waste.

Section 724.410 (Closure and Post-Closure Care) defines the minimum requirements for landfill covers, which are:

- Provide long-term minimization of migration of liquids through the closed landfill;
- Function with minimum maintenance;
- Promote drainage and minimize erosion or abrasion of the cover;
- Accommodate settling and subsidence so that the cover's integrity is maintained; and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

At the LCC site, there is no manmade or installed liner system. Waste material was placed at and/or beneath the water table, with the aquifer soil consisting primarily of fine silty sand. Located approximately beneath the aquifer is a clay lens, which acts as an aquitard. The characteristics of this clay layer across the site are poorly defined. Given that waste material is in direct contact with groundwater and the clay layer is not clearly defined, a standard hydraulic permeability cannot readily be established for this regulation.

While 35 IAC 724 was established to address hazardous waste treatment, storage, and disposal facilities, the EPA issued a technical guidance document, *Final*

Covers on Hazardous Waste Landfills and Surface Impoundments (EPA 1989), which can be used to establish the criteria for meeting the intent of 35 IAC 724.

The cover system presented in the EPA guidance document is a multilayer design consisting of a vegetated top layer, drainage layer, and low-permeability layer. It should be noted that within the document, it is stated that the recommendations for the proposed cover design are guidance only and not regulations.

The guidance document recommends the following cap design:

- A top layer of at least 60 centimeters of soil either vegetated or armored at the surface;
- At a minimum, a 12-inch-thick granular or geosynthetic drainage layer with a hydraulic transmissivity of not less than 3×10^{-5} square centimeters per second (cm^2/sec); and
- A two-component low-permeability layer composed of a 20-millimeter-thick flexible membrane liner (FML) installed directly on a 24-inch-thick compacted soil layer having a hydraulic conductivity no greater than 1×10^{-7} cm^2/sec .

It also states that optional layers may be needed (i.e., biotic barrier, gas vent layer, etc.).

As stated above, the guidance document recommends the low-permeability layer to be a two-part system, which consists of an FML and a compacted soil layer. While a two-part low-permeability layer is recommended, it is not required. To further support a single, low-permeability layer system, the State of Illinois's 92nd General Assembly directed the Illinois EPA to study the merits and effectiveness of multiple liner systems at Illinois landfills and provide a recommendation on the advisability of requiring multiple liner systems. The report, *A Study of the Merits and Effectiveness of Alternate Liner Systems at Illinois Landfills*, recommends against modifying the Illinois regulations to change the minimum liner design requirement from a single liner to a double-composite liner. Finally, 35 IAC 724 does not require a multicomponent low-permeability layer.

By using recommendations of the EPA guidance document, the minimum Federal standards for a hazardous waste cover can be stated as:

- Provide long-term minimization of migration of liquids through the closed landfill;

- Function with minimum maintenance;
- Promote drainage and minimize erosion or abrasion of the cover;
- Accommodate settling and subsidence so that the cover's integrity is maintained;
- At a minimum, use a 12-inch-thick granular or geosynthetic drainage layer with a hydraulic transmissivity of not less than $3 \times 10^{-5} \text{ cm}^2/\text{sec}$; and
- The low-permeability layer shall be composed of not less than a 24-inch-thick compacted soil layer having a hydraulic conductivity not greater than $1 \times 10^{-7} \text{ cm}^2/\text{sec}$.

Since isolated areas of LCC site soils are classified as characteristic hazardous waste based on previous TCLP analysis of site soils, and since the site has a history of waste products being brought to the site for disposal, 35 IAC 724 and 811 are considered to be relevant and appropriate.

In addition to the ARARs associated with the cap construction, there are ARARs associated with post-closure care. For a cap placed on a hazardous waste landfill, 35 IAC 724.410 would be considered an ARAR, and, for a non-hazardous waste landfill, 35 IAC 811.110, 811.111, and 811.314 would be considered ARARs. Post-closure care includes scheduled inspections and repairs (if necessary) to ensure the cap integrity is maintained; groundwater monitoring of the contaminant plume; and placement of deed restrictions.

While the LCC site does not readily fit into a single category with regard to landfill covers and/or post-closure requirements, all three regulations have requirements that are relevant to the final presumptive remedy of capping. In evaluating the various alternatives in Section 4, the discussion will focus on the ability of individual alternatives to meet these regulations.

RCRA and Waste Management

RCRA provides guidelines for the control of hazardous waste from generation through transportation, treatment, storage, and disposal. The Illinois Administrative Code adopts the Federal regulations. RCRA guidelines pertain to the identification of hazardous waste (40 CFR 261). If all waste at the LCC site is incorporated into a capped unit, and no waste is transported off site, these requirements will not apply. However, if residual wastes are generated in the course of the remedial action (e.g., rinsate from decontamination of heavy equipment that comes in contact with hazardous waste), and such waste must be transported off site for disposal, these requirements would apply. While consolidation will be kept to a minimum and the majority of excavation spoils

will remain on site, there may be some materials that require off-site disposal that will need to be characterized for proper treatment/disposal. Those wastes that contain a RCRA-listed constituent or exhibit hazardous characteristics would have to be managed, treated, and disposed of as hazardous waste. Activities involving hazardous waste must comply with Illinois requirements listed in Table 2-3. Activities involving wastes determined to be non-hazardous must comply with Illinois requirements for solid waste management.

Clean Water Act

The Federal Clean Water Act (CWA), adopted under Illinois water pollution laws, regulates the discharge of pollutants to surface waters of the State and may be applicable to remedial activities because of the proximity of the site to Lake Calumet and the Calumet River and the potential discharge of surface runoff during the remedial action. Any discharge from the site that could impact surface water bodies would need to comply with chemical-specific discharge limits (as discussed above).

As noted previously, Section 303.441 of Title 35 of the Illinois Administrative Code designates the Little Calumet River, the Grand Calumet River, and Lake Calumet as secondary contact and indigenous aquatic life waters (as opposed to drinking water sources). Therefore, the standards that apply to these water bodies are specified in Part 302 Subpart D, including standards for pH, dissolved oxygen, chemical constituents, and toxic substances. For a remedial action to meet this ARAR, it must limit any surface runoff of contamination from the site that would lead to an exceedance of the water quality criteria for these water bodies.

Subpart A of 35 IAC Section 304 establishes general effluent standards. Section 304.141 requires that any discharge of wastewater comply with effluent limits stipulated in a facility's NPDES permit, and forbids discharge of any pollutant for which a facility does not have permit-established effluent standards that would cause violation of water quality standards in a receiving water body. These requirements would be applicable to the discharge of any wastewater to surface waters during the course of the remedial action or after completion of the remedial action.

Clean Air Act

The Federal Clean Air Act (CAA), adopted under Illinois law, regulates the discharge of pollutants to the air of the State. The CAA may be applicable to remedial activities because landfill gas will be collected at the LCC site with the vacuum and subsequent treatment provided by the Paxton II Landfill flare system, which is located to the immediate north of the site.

Therefore, 35 IAC 811.311 (Landfill Gas Management System) outlines the actual construction and performance requirements associated with the gas

extraction system. Treatment, discharge and the associated permits for emitting combusted landfill gas to the atmosphere would be covered under 35 IAC 811.312 (Landfill Gas Processing and Disposal System). Given that the flare system at Paxton will be used, and no additional equipment outside of the collection header piping and valves would be installed at the LCC site, an air permit for the LCC site would not be required. However, 35 IAC 811.312 is still considered to be relevant because a permit modification may have to be obtained to add the LCC site landfill gas to the influent gas generated at Paxton II.

Additionally, 35 IAC 811.312 further references that the discharge permit from a flare system must include the six criteria air pollutants and the hazardous air pollutants subject to regulation under the Clean Air Act (42 U.S. C. 7401 et seq.). Finally, the air discharge permit must also meet the requirements of 35 IAC 200 through 245.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) addresses the manufacture, handling, and disposal of specific toxic substances, including PCBs. Because PCBs have been detected at significant concentrations at the LCC site, TSCA requirements apply to actions addressing PCB-containing materials.

The ARARs and TBCs identified in Tables 2-1, 2-2, and 2-3 enter into the evaluation of remedial alternatives, discussed in Section 4 of this report. The list of ARARs and TBCs will be refined as a preferred alternative is selected, and final ARARs will be presented in the Interim Remedial Action Record of Decision (IROD).

2.2.3 Cleanup Goals

The final step required for the development of RAOs is to establish cleanup goals based on chemical-specific ARARs, TBCs, and COPCs and CPECs. The aim of remedial action objectives is to meet ARARs and eliminate exposure to contaminants of concern such that human health and the environment are adequately protected. This can be achieved by eliminating exposure pathways (which is discussed in the upcoming Section 2.3, Identification of General Response Actions) or reducing contaminant concentrations to levels that are accepted to be adequately protective of human health and the environment.

This FFS follows the presumptive remedy for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) municipal landfill sites and focuses on capping to eliminate exposure pathways. Therefore, establishing cleanup concentrations by review of state and federal laws, regulations, and guidance documents, and identification of any chemical-specific ARARs or TBCs, is not necessary. Furthermore, no chemical-specific cleanup goals will be

established for LFG in this FFS since a collection system will be proposed that will also limit any exposure pathways.

2.3 Identification of General Response Actions

Based on the information derived from previous investigations, general response actions are identified for each medium of interest. General response actions can be considered conceptual alternatives for each medium of interest that will satisfy the remedial action objectives. The “no-action” alternative is included as a general response action for each medium of interest to serve as a basis for comparison with other potential response actions.

2.3.1 Soil and Waste

The general response actions for soil identified in this section address the pathways of direct contact (e.g., inhalation, dermal adsorption, and ingestion) and leaching. Containment (capping) would prevent direct contact with potential receptors and reduce leachate production resulting from surface water infiltration. Excavation, treatment, and disposal would remove, immobilize, or destroy waste material and soil contaminants, as well as remove the source of contamination. Excavation, treatment, and disposal would eliminate the potential for direct contact with the wastes, and leaching of contaminants into groundwater. The no-action alternative would leave the soils and wastes in their present condition, but may include institutional controls (e.g., fencing or deed restrictions), which would limit site access, thereby reducing the potential for exposure to contaminants.

2.3.2 Groundwater

Groundwater response actions are not being considered in this document. However, groundwater monitoring will be a component of the operations and maintenance for the selected remedy.

2.3.3 Leachate

Leachate response actions are not being considered in this document other than preventing/reducing the amount of leachate generation.

2.3.4 Landfill Gas

General response actions for LFG include gas collection and/or treatment, institutional actions, and no action. Except for the no-action response, these response actions would reduce exposure of the public to emissions exceeding benchmark concentrations for the COPCs. The no-action alternative would allow for continued dissipation of LFG. Under this FFS, response actions are only considered when necessary to protect capping systems or to prevent off-site lateral migration.



2.3.5 Surface Area and Volume Estimation of Contaminated Media

Land Disposal Areas and Volumes

The surface area of the site was obtained using the boundaries established in a 1999 aerial photograph obtained from Patrick Engineering Inc. Based on this aerial photograph and adding to the north boundary to tie into the Paxton I landfill cap, it is estimated that the site encompasses an area of approximately 90 acres. Total fill volumes were obtained from estimates in Clayton Group Services, Inc.'s (Clayton's) *Remedial Options Report for the Southeast Chicago Cluster Site*, Volume 1 of 2. Reported fill areas are estimated to be up to 30 feet in depth; based on this value and using a site area of 76 acres, Clayton estimated a total fill volume in excess of 4.75 million cubic yards (Clayton 2002).

Gas Production Rates

Methane gas production in landfills can be associated with the anaerobic decomposition of organic materials in the landfill and depends on the moisture content of the waste. (The highest generation rates occur between 60% and 80% saturation.) Since significant concentrations of organic vapors were documented during the test pit excavations, for the purposes of this FFS it has been assumed that methane is being generated and that a gas collection system will be required. It should also be noted that a methane survey may be performed at the site as part of the engineering design effort.

2.4 Identification of Applicable Remedial Technologies

Applicable remedial technologies are identified below for each general response action. The section has been refined by retaining only those remedial technologies appropriate for the LCC site, taking into account the following:

- Site conditions and characteristics that may affect implementability of the technology;
- Physical and chemical characteristics of contaminants that determine the effectiveness of various technologies; and
- Performance and operating reliability of the technology.

2.4.1 Soil and Waste

Existing site information was reviewed to determine future probable property use. As indicated by the site history and analytical results from site investigations, the site consists of multiple disposal areas generally extending to a depth of 30 feet. The agglomeration of disposal areas makes up what could be considered a non-permitted landfill. The most likely future use of the property is as open space. This evaluation assumes that the site would not be accessible to people with the exception of periodic on-site operations and maintenance (O&M) work.

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The first step in the development of remedial alternatives was to screen available, viable remedial technologies that could be applied to the site. The list of potential remedial technologies was quickly narrowed because VOCs, SVOCs, and metals were all present above acceptable risk levels at the site. Most technologies currently available are not able to address both organics and inorganic contamination. Additionally, the various organics present in at the site are generally remediated by different methods (i.e., anaerobic degradation for tetrachloroethene (PCE) and aerobic degradation for benzene). The immense volume of waste present at the site (in excess of 4.75 million cubic yards assuming a total depth of 30 feet [Clayton 2002]) makes any option focused on removal or treatment of the total volume economically infeasible. Technologies that were considered but eliminated during the initial screening include:

1. Bioremediation;
2. Chemical destruction/detoxification (oxidation/reduction, dehalogenation, neutralization);
3. Thermal treatment (incineration, in situ vitrification, pyrolysis);
4. Chemical/physical extraction (soil vapor extraction, soil flushing, soil washing);
5. Thermal desorption (low temperature thermal desorption, steam stripping);
6. Immobilization (stabilization/solidification, fixation); and
7. Soil aeration.

Although not technically a landfill, the LCC site has the same characteristics as a non-permitted abandoned landfill. The permeable cover allows substantial infiltration of water through the waste, contaminated shallow groundwater is present possibly due to this infiltration, regional shallow groundwater flow is present, and contaminant types (i.e., organics, metals, pesticides, etc.) are not specific to a particular area due to widespread dumping of various wastes. Because of the uncertainty about specific site contents and their location, it is impossible to fully characterize, excavate, and/or treat independent source areas. Characterization of landfill contents is not necessary for selecting a remedial option, but existing data are used to determine whether the containment presumption is appropriate. Based on the similarities, the site is a prime candidate for evaluating the presumptive remedies developed by the EPA for abandoned or inactive landfills. The EPA, in its guidance document entitled *Presumptive Remedy for CERCLA Municipal Landfill Sites* (1993), has indicated that the presumptive remedies for source containment at a landfill site include:

1. Landfill cap;
2. Source area groundwater control to contain the plume;
3. Leachate collection and treatment;
4. Landfill gas collection and treatment; and/or
5. Institutional controls to supplement engineering controls.

The screening process was completed by concluding that the remedial alternatives to be evaluated for the site would focus on the presumptive remedies for an inactive landfill. This FFS concentrates on landfill cover systems to prevent surficial migration and surface water infiltration. Horizontal and vertical barriers for controlling groundwater migration are beyond the scope of this document.

Alternatives for the site include a combination of approaches, all of which involve an engineered cover. Cover designs not considered include asphalt-, concrete-, and chemical-based covers. Soil covers, clay caps, and multi-layer caps are considered. A number of different variations of these elements are technically feasible; however, alternatives that include wide-spread excavation or consolidation of wastes are not evaluated. The alternatives evaluated include:

1. No Action;
2. Capping of existing wastes with a permeable soil cover;
3. Capping of existing wastes with an evapotranspiration (ET) cap;
4. Capping of existing wastes with a low-permeability 35 IAC Part 724 clay cap; and
5. Capping of existing wastes with a low-permeability 35 IAC Part 811 clay cap.

2.4.2 Landfill Gas

Remedial technologies for LFG are used to collect, remove, or treat gases generated by landfills. Disposal of LFG is accomplished by venting the treated or untreated LFG to the atmosphere. Applicable technologies include passive systems, active systems, thermal treatment, and physical treatment. Because an on-site flare that has the capacity to accept LFG from the LCC site is currently present on the Paxton II landfill, it will be assumed that an active gas collection system will be a component for all of the interim remedial action alternatives that have a low-permeability component.

2.4.3 Leachate

Leachate collection is not part of OU1 and is not discussed within this FFS.

2.4.4 Surface Water

Run-on and run-off management and collection systems are used to remove excess surface water from the cap and prevent infiltration through the low-permeability layers. Any remedy selected will be required to address surface water. Because of the large area to be drained, it is assumed that the water will need to be collected at several low points in catch basins. The catch basins would feed a system of underground piping that would drain to the low area at the northeast corner of the site. The surface water would then be combined with surface water from the Paxton I and Paxton II sites before flowing off the

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northwest corner of the Paxton II site to Lake Calumet. The option to discharge surface waters to Indian Ridge Marsh will also be explored during the design phase of the project.

2.4.5 Groundwater

Groundwater remediation is not part of OU1; however, groundwater monitoring will be a component of the operations and maintenance for any selected remedy.

2.4.6 Construction Quality Assurance Program

The CQA program ensures the structural stability and integrity of all components, proper construction of all components, and conformity of all materials used with design or other material specifications. A construction quality assurance (CQA) program is required in accordance with 35 IAC 724.119.

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Table 2-1 Chemical-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
State Chemical-Specific ARARs and TBCs					
Illinois Environmental Protection Act, Pollution Control Board	Risk Based Cleanup Objectives	Title 35 IAC, Subtitle G, Chapter I, Subchapter f	Part 740 - Site Remediation Program Part 742 - Tiered Approach to Corrective Action Objectives	TBC	In areas where waste is removed, pertinent for establishing cleanup goals for remaining soils and engineered barriers
Federal Chemical-Specific ARARs and TBCs					
Clean Water Act 33 USC 1313	Federal Total Maximum Daily Loads (TMDLs)	40 CFR Part 130.7	Requires states to identify impaired waters and to establish TMDLs to ensure that water quality standards can be attained	Potentially Relevant	
Clean Air Act 33 USC 7401	Air Quality Standards	40 CFR Part	Establish Federal standards for various pollutants from both stationary and mobile sources	Potentially Applicable	
EPA Directive #9355.4-12, July 1994	Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites		Guides establishment of cleanup standards for lead	TBC	May be pertinent for lead in areas where waste will be removed for consolidation
RCRA Subtitle C	Groundwater Protection Standards	40 CFR 264.92-264.101	Sets standards for groundwater at RCRA facilities.	Not Applicable for this action	Cleanup of groundwater is not a goal of this interim action;
Toxic Substances Control Act	Rules for Cleanup of PCBs	40 CFR 761.125	Provides guidance on cleanup of PCB-contaminated materials	Potentially Applicable	Relevant for establishing cleanup goals for PCBs in areas where waste will be removed

Note: Some chemical-specific ARARs listed above are also discussed as action-specific ARARs. Some requirements can serve to establish remedial objectives as well as impact the actual implementation of a given remedial alternative.

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Table 2-2 Location-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
State Location-Specific ARARs and TBCs					
Illinois Environmental Protection Act, Pollution Control Board	Secondary Contact Waters	Title 35 IAC, Section 303.441	Designates Lake Calumet and Calumet River as secondary contact and indigenous aquatic life waters	Potentially Relevant	For this category of surface waters, different water quality standards apply; pertinent for any wastewater discharges in the course of the remedial action
Illinois Endangered Species Protection Act, Illinois Department of Natural Resources	Endangered Species	Title 17 IAC, Part 1075	Requires consultation with DNR by other state/local agencies prior to acts that may affect T & E species	Potentially Applicable	Relevant if T&E species in vicinity of site
Illinois Interagency Wetlands Policy Act	Wetlands Protection	Title 17 IAC, Part 1090	Requires DNR review of any state-funded action that may impact wetlands	Potentially Relevant	
Illinois Department of Natural Resources	Floodplain Construction	Title 17 IAC, Part 3706	Restricts construction activities in floodplain	Not Applicable	
Federal Location-Specific ARARs and TBCs					
Executive Order No. 11990	Wetlands Protection	40 CFR § 6.302(a) and Appendix A	Minimizes impacts to wetlands.	Potentially Applicable	
Executive Order No. 11988	Floodplain Management	40 CFR § 6.302 and Appendix A	Regulates construction in floodplains.	Potentially Applicable	
Wild and Scenic Rivers Act	Waterway Protection	16 USC §§ 1271-1287 40 CFR § 6.302(e) 36 CFR Part 297	Establishes requirements to protect wild, scenic, or recreational rivers.	Not Applicable	No regulated rivers impacted
Wilderness Act	Wilderness Protection	16 USC 1311, 16 USC 668 50 CFR 53, 50 CFR 27	Limits activities within areas designated as wilderness or National Wildlife Refuge.	Not Applicable	Not a wilderness area

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Table 2-2 Location-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Fish and Wildlife Coordination Act	Wildlife Protection	16 USC § 661 et seq. 40 CFR § 6.302(g)	Requires coordination with Federal and State agencies to provide protection of fish and wildlife.	Potentially Applicable	
Endangered Species Act	Species and Habitat Protection	16 USC §§ 1531-1543 50 CFR Parts 17, 402 40 CFR § 6.302(b)	Regulates the protection of threatened or endangered species.	Potentially Applicable	Relevant if T&E species are present in vicinity of site
Section 404, Clean Water Act	Dredging/Fill	33 USC 1251 et seq. 33 CFR Part 330	Regulates discharge of dredging or fill materials into waters of the United States	Not Applicable	
Migratory Bird Treaty Act	Migratory Birds	16 USC § 703-12	Requirement for agencies to examine proposed actions by the government relative to habitat impacts and impacts to individual organisms	Potentially Applicable	
Executive Order No. 12962	Recreational Fisheries	16 USC § 742a-d and e-j; 16 USC § 661-666c; 42 USC § 4321; and 16 USC § 1801-1882	Requirement that Federal agencies improve the quantity, function, and sustainable productivity, and distribution of U.S. aquatic resources for increased recreational fishing opportunities	Potentially Applicable	

Note: Location-specific ARARs and TBCs apply to sites that contain features such as wetlands, floodplains, sensitive ecosystems, or historic buildings that are located on or close to the site. Because of the presence of wetlands, floodplains, and sensitive ecosystems close to the site, location-specific ARARs and TBCs may be pertinent for the remedial action.

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Table 2-3 Action-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Local Action-Specific ARARs and TBCs					
Chicago Municipal Code	Waste-Water Management	Chapter 11-4 (Utilities and Environmental Protection), Article VI	Standards for the discharge of waste-water	TBC	Relevant to construction-related activities or waste-water treatment.
	Solid and Liquid Waste Control	Chapter 11-4 (Utilities and Environmental Protection), Article IX	Standards for treating or disposing of solid or liquid waste	TBC	Relevant to waste streams generated in the course of remedial action
	Air Pollution Control	Chapter 11-4 (Utilities and Environmental Protection), Article II	Emission standards for smoke, visible emissions, carbon monoxide and nitrogen	TBC	General limits for emissions – may be relevant to dust emissions generated in the course of remedial action
	Reprocessable Construction/Demolition Material	Chapter 11-4 (Utilities and Environmental Protection), Article XIV	Requirements for recycling construction/demolition waste	TBC	
	Noise and Vibration Control	Chapter 11-4 (Utilities and Environmental Protection), Article VII	Establishes general noise limits	TBC	General restriction on 'excessive noise'
Cook County Environmental Control Ordinance	Emission Standards and Limitations for Stationary Sources	Article VI	Emission standards for smoke, visible emissions, particulates, sulfur, organic material, carbon monoxide, nitrogen oxides	TBC	Limitations for emissions from capped landfills, including flare for landfill gas

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Table 2-3 Action-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Cook County Environmental Control Ordinance (Cont.)		Article 6.12	Materials Subject to Becoming Windborne	TBC	Requires control of windborne emissions during consolidation of waste, prior to capping
	Noxious, Odorous, and Toxic Matter	Article VIII	General prohibition of emissions of substances that threaten public health, comfort, or welfare	TBC	
	Noise and Vibration Control	Article 9.6	Restricts hours of operation of construction equipment if in proximity to buildings	Not applicable	No residential or hospital buildings within 600 feet
	Solid Waste Management	Articles 9.7, 9.9- 9.13	Restricts idling of vehicles and vehicle noise levels	TBC	
	New Pollution Control Facility Siting Ordinance	Article XI	Coordination of municipal efforts to manage solid wastes	Not Applicable	Has no bearing on actual waste management practices
State Action-Specific ARARs and TBCs Illinois Environmental Protection Act, Pollution Control Board		Article XII	Application and Approval Process for New Facility Siting	Not Applicable	Only for new facilities in unincorporated areas of Cook County
	Emission Standards and Limitations for Stationary Sources	35 IAC 212.301, 212.315, 212.316(c)	Emission standards for visible emissions, vehicle covers, and roadway emissions	Potentially Applicable	Relevant to emissions during construction operations
	Non-methane Organic Compounds	35 IAC 220 Subpart B	Landfill gas collection and flare systems	Potentially Applicable	Relevant to emissions from landfill gas flare
	Toxic Air Contaminants	35 IAC 232	Emission restrictions for toxic contaminants	Potentially Applicable	Relevant to emissions from landfill gas flare
	Water Quality	35 IAC 302 Subpart D	Water quality standards for secondary contact waters	Potentially Applicable	Relevant to surface runoff during and after remedial action
	Permits	35 IAC 703.121 and 703.207	RCRA permit program and waste stream authorization	Potentially Relevant and Appropriate	While RCRA permits are typically not required for Superfund Remedial Actions, the requirements of such permits are often relevant
	Hazardous Waste Operating Requirements	35 IAC 721 and 723	Identification, transportation, and disposal of hazardous wastes	Potentially Applicable	Relevant to off-site transport of remediation derived wastes

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Table 2-3 Action-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Illinois Environmental Protection Act, Pollution Control Board (Cont.)	Illinois Superfund Program	35 IAC 750	Establishes procedures for assessing and remediating Illinois State Superfund sites	Applicable	See text
	Solid Waste and Special Waste Hauling	Subtitle G, Chapter I, Subchapter i	Regulates classification, transport, and disposal of solid and special waste	Potentially Applicable	Relevant to transport and disposal of non-hazardous remediation-derived waste; landfill requirements may be relevant and appropriate for capped area (refer to federal requirements)
	Noise	Subtitle H	Sound emission standards and limitations	Potentially Applicable	For construction equipment during remedial action; because of surrounding land use, may not be relevant
	Hazardous Waste Cover Systems	35 IAC 724, Subpart N	Standards for hazardous waste landfill cover systems	Potentially Applicable	
	Closure and Post-Closure Care	35 IAC 724.410	Closure and post-closure requirements for hazardous waste landfills	Potentially Applicable	
	Leachate Collection	35 IAC 724.401(c)(2)	Liner requirements and collection and removal standards	Not Applicable to OUI	Not relevant to this phase of the project
	Run-on and Run-off Management and Collection Systems	35 IAC 724.401(g), (h), and (i)	Establish requirements for run-on prevention, run-off design storm, and holding facilities	Potentially Applicable	
	Groundwater Monitoring	35 IAC 724 Subpart F	Groundwater protection standards, point of compliance, and detection monitoring programs	Potentially Applicable	A component of operations and maintenance
	Construction Quality Assurance Plan	35 IAC 724.119	CQA written plan components and contents of program, inspection and sampling requirements	Potentially Applicable	Relevant and appropriate for landfills
	Non-hazardous Waste Cover Systems	35 IAC 811, Subpart C	Standards for putrescible and chemical waste landfill cover systems	Potentially Applicable	

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Table 2-3 Action-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Illinois Environmental Protection Act, Pollution Control Board (Cont.)	Closure and Post-Closure Care	35 IAC 811.110, 811.111, 811.314	Closure and post-closure requirements for non-hazardous waste landfills	Potentially Applicable	
	Landfill Gas Management	35 IAC 811.311	Establish minimum requirements for gas venting and collection systems	Potentially relevant	
	Landfill Gas Processing and Disposal System	35 IAC 811.312	Establishes treatment, discharge and permitting requirements for combusted landfill gas	Potentially relevant	
	Steel and Foundry Industry Wastes	35 IAC 817	Standards for management of beneficially usable wastes	Potentially Applicable	
Federal Action-Specific ARARs and TBCs					
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and Superfund Amendments and Reauthorization Act of 1986 (SARA)	National Contingency Plan	40 CFR 300, Subpart E	Outlines procedures for remedial actions and for planning and implementing off-site removal actions.	Potentially Applicable	
Occupational Safety and Health Act	Worker Protection	29 CFR 1904, 1910, and 1926	Specifies minimum requirements to maintain worker health and safety during hazardous waste operations. Includes training requirements and construction safety requirements.	Potentially Applicable	Under 40 CFR 300.38, requirements of OSHA apply to all activities that fall under jurisdiction of the National Contingency Plan.
Executive Order	Delegation of Authority	Executive Order 12316 and Coordination with Other Agencies	Delegates authority over remedial actions to federal agencies	Potentially Applicable	

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Table 2-3 Action-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Clean Water Act	National Pollutant Discharge Elimination System (NPDES)	40 CFR 122 and 125	Issues permits for discharge into navigable waters. Establishes criteria and standards for imposing treatment requirements on permits.	Potentially Applicable	Relevant for any wastewater discharges in the course of the remedial action
Clean Air Act	National Primary and Secondary Ambient Air Quality Standards	40 CFR 50	Establishes emission limits for six pollutants (SO ₂ , PM ₁₀ , CO, O ₃ , NO _x , and Pb).	Potentially Applicable	Potentially relevant for landfill gas flare emissions
	National Emission Standards for Hazardous Air Pollutants	40 CFR 61	Provides emission standards for 8 contaminants. Identifies 25 additional contaminants as having serious health effects but does not provide emission standards for these contaminants.	Potentially Applicable	Potentially relevant for landfill gas flare emissions
Toxic Substances Control Act	Rules for Controlling PCBs	40 CFR 761	Provides guidance on storage and disposal of PCB-contaminated materials	Potentially Applicable	Relevant for transport of any PCB-containing materials, if any such materials generated in the course of the remedial action is removed from the site
Resource Conservation and Recovery Act	Criteria for Municipal Solid Waste Landfills	40 CFR 258	Establishes minimum national criteria for management of non-hazardous waste.	Potentially Applicable	Applicable to remedial alternatives that involve generation of non-hazardous waste. Non-hazardous waste must be hauled and disposed of in accordance with RCRA.
	Hazardous Waste Management System - General	40 CFR 260	Provides definition of terms and general standards applicable to 40 CFR 260 - 265, 268.	Potentially Applicable	Applicable to remedial alternatives that involve generation of a hazardous waste (e.g., contaminated remediation-derived waste). Hazardous waste must be handled and disposed of in accordance with RCRA.
	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies solid wastes that are subject to regulation as hazardous wastes.	Potentially Applicable	

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Table 2-3 Action-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Resource Conservation and Recovery Act (Cont.)	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes requirements (e.g., EPA ID numbers and manifests) for generators of hazardous waste.	Potentially Applicable	
	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards that apply to persons transporting manifested hazardous waste within the United States.	Potentially Applicable	
	Standards Applicable to Owners and Operators of Treatment, Storage, and Disposal Facilities	40 CFR 264	Establishes the minimum national standards that define acceptable management of hazardous waste.	Potentially Applicable	Applicable to construction of site cap and to any off-site treatment/disposal of remedial-action generated waste
	Standards for owners of hazardous waste facilities	40 CFR 265	Establishes interim status standards for owners and operators of hazardous waste treatment, storage, and disposal facilities.	Potentially Applicable	
	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes that are restricted from land disposal.	Potentially Applicable	
	Hazardous Waste Permit Program	40 CFR 270, 124	USEPA administers hazardous waste permit program for CERCLA/Superfund Sites. Covers basic permitting, application, monitoring, and reporting requirements for off-site hazardous waste management facilities.	Potentially Applicable	
EPA Publication	Design and Construction of RCRA/CERCLA Final Covers	EPA/625/4-91/025	Describes design and construction of caps for CERCLA Landfills	TBC	
	Design and Construction of Covers for Solid Waste Landfills	EPA/6002-79/165	Describes design and construction of caps for landfill caps	TBC	

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Table 2-3 Action-Specific ARARs and TBCs, Lake Calumet Cluster Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
EPA Publication (Cont.)	Standardized Procedures for Planting Vegetation on Competed Sanitary Landfills	EPA/600/2-83/055	Describes planting procedures for vegetative layers	TBC	
	Covers for Uncontrolled Hazardous Waste Landfills and Surface Impoundments	EPA/530/SW-89/047	Describes design and construction of caps for uncontrolled waste sites	TBC	
	Presumptive Remedies: CERCLA Landfill Caps RI/FS Data Collection Guide	EPA/540/F-95/009			

3

Development of Remedial Alternatives

Currently, the LCC site is covered with soil, slag, cinders, and various other construction debris with depths generally ranging from 0 to 3 feet. Test pit excavations found fill thicknesses ranging from 0 to greater than 30 feet BGS. Based on the results of the soil investigation, contamination was detected in surface soils, and there are several locations where little to no soil cover exists and contact with waste material is possible. Additionally, the bulk of waste located on site is beneath the water table, allowing contaminants to leach directly into the groundwater.

Under an intergovernmental agreement (IGA) with the Illinois EPA, the Illinois Department of Transportation (IDOT) has been exporting excess native soils from their Dan Ryan Expressway Reconstruction Project to the LCC site. This soil varies from sand to clay with the majority of the material being silty-clay to clay. The material imported to the LCC site is tested by IDOT prior to shipment to the site to ensure that the standards of the IGA are met. The IGA requires all soils to meet the TACO Tier 1 Soil Remediation Objectives for Residential Properties (35 IAC 742, Appendix B, Table A). The IAG also requires the soils to not contain any contaminants that are not listed on the Target Compound List found in 35 IAC 740, Appendix A, to contain only native soils, to be visually inspected, and not to have been used as fill material.

In addition to the Tier 1 requirements, the IGA establishes acceptable levels for PAHs, which are based on background concentrations for the City of Chicago, Metro, and Non-Metro areas.

Whenever IDOT imported soils are referenced within this document, it should be assumed that these soils meet the IGA standard. There are approximately 300,000 cubic yards of material currently on site, and it is estimated that the total volume of imported soils may reach as much as 1 million cubic yards. Once the soil reaches the site, it is sorted into piles based on a visual inspection.

Given the amount of the soil that will be required as part of the action alternatives, it has been assumed, wherever possible, that the IDOT material will be incorpo-

rated as part of the alternative. It should be noted that this use is dependent upon the material's properties. For the purposes of alternatives development, it has been assumed that once the clay material is compacted, it will achieve a hydraulic conductivity of 1×10^{-7} centimeters per second.

The alternatives have been developed to mitigate potential threats posed by LCC site contaminants. These alternatives were also developed based on Federal and Illinois State guidance as described below.

Using the presumptive remedy of a cover across the LCC site, five cover/cap alternatives, including the No Action alternative, have been developed and are presented in this section. In Section 4, the alternatives are evaluated individually and comparatively using the criteria established by the EPA.

3.1 Alternative 1: No Action

Under this alternative, no action would be taken to remove, treat, or contain contaminated soils, wastes, and groundwater at the site. Because contaminated media would remain in place, the potential for continued migration of contaminants would not be mitigated. Additionally, no institutional controls would be implemented to prevent intrusive activities into the waste materials. The No Action alternative has been included as a requirement of the National Contingency Plan (NCP) and to provide a basis for the comparison for the remaining alternatives.

This alternative does not improve on the minimal protection already provided by the existing cover soils, nor is it considered a permanent remedy because it does not reduce the toxicity, volume, or mobility of the hazardous waste on the site. The resultant risks associated with the No Action alternative would be the same as those identified in the human health and ecological risk evaluations.

3.2 Alternative 2: Capping of Existing Wastes with a Permeable Soil Cover

Description of Remedial Alternative

Alternative 2 involves construction of a permeable soil cover over the existing wastes including creation of an appropriate grade for stormwater retention. Activities comprising this alternative include site preparation/grading, placement of the cover material, and planting of a vegetative cover, which would consist of native plants and prairie grasses. Groundwater monitoring is included as a component of the operations and maintenance for this alternative.

Site Preparation

Site preparation would be performed before any disturbance of the existing surface is initiated. The purpose of site preparation is to remove on-site structures and vegetation that would affect the cover construction, and to control and collect runoff during construction. Three small structures will be demolished and disposed of off site following assessments for asbestos-containing materials and lead. Site runoff can potentially be contaminated by contact with the waste and sediment from exposed soils. Temporary collection ponds would be built, and silt fencing or straw bales located along downstream perimeters will prevent sediment-laden water from flowing off site. Following implementation of these measures, clearing, grubbing, and removal of the existing vegetation on site is necessary to facilitate further operations. Woody and brushy material can be chipped for volume reduction, and may be reusable as mulch elsewhere. The vegetation removal would be done in phases preceding earthwork operations to minimize erosion impacts.

The TCLP results obtained from previous investigations indicate that there are four sampling locations that contained wastes characteristically hazardous for either metals or VOCs (Clayton 2002). The Illinois EPA will need to evaluate whether any of these wastes would be regulated as hazardous waste under this alternative, and require removal and off-site disposal.

Access restrictions will also be enacted, in the form of deed restrictions and fencing (groundwater restrictions already exist within the limits of Cook County, Illinois). Deed restrictions would be placed on the use of land within the site boundaries. A clause prohibiting future development or excavation of the contaminated areas would be added to the property deed or deeds that include the site. Additionally, fencing will be constructed around the perimeter of the entire site to limit access.

Soil Cover and Vegetation

Following completion of site preparation, a grading layer would be constructed on the site to attain the final site contour followed by a 2.5-foot-thick permeable soil cover. Perimeter waste may need to be excavated and consolidated on site to move it away from the site property edges. As necessary, additional fill will be imported and placed to develop an acceptable slope for proper drainage. The soil cover will consist of an uncompacted, medium-permeability soil, such a loam or sandy loam. The site will be contoured in such a way that all precipitation will be held on site and allowed to infiltrate. Biosolids will be incorporated into the top 6 inches of soil cover to provide a vegetative layer. Figure 3-1 shows a plan view of the site following remedial action. Figure 3-2 illustrates the proposed cross section for this alternative. Native short-rooted prairie grasses would be used for vegetation of the site based on their low maintenance requirements and compatibility with the end use for the site.

Effectiveness and Cost

The principal “functional” element of this alternative is the permeable soil cover. The soil cover will not prevent precipitation from pooling and infiltrating into the waste; therefore, the volume and rate of flow of surface water into the fill will not diminish. The alternative also fails to address the collection and destruction of generated LFG. This alternative does not provide a great deal of flexibility with respect to future land uses, since any excavation or drilling would be prohibited from disturbing the soil cover, although almost any “surface only” land use could be accommodated. Since wastes are being left virtually undisturbed under this alternative, except for possible consolidation of perimeter waste, the general surface elevation of the site will be raised, which would necessitate the construction of perimeter berms to collect and control stormwater runoff and prevent it from flowing off site.

The cost to construct Alternative 2 is estimated to be \$10,999,000, and yearly operations and maintenance (O&M) will cost approximately \$65,000. Assuming 30 years of O&M will be required and an inflation rate of 5%, the net present worth of this alternative is estimated to be \$11,900,000. Table 3-1 summarizes the cost estimates for Alternative 2. Detailed cost estimate tables for each alternative are included in Appendix C.

3.3 Alternative 3: Capping of Existing Wastes with an Evapotranspiration (ET) Cap**Description of Remedial Alternative**

Alternative 3 involves construction of an ET soil cap over the existing wastes and creation of an appropriate grade for stormwater retention. This alternative involves construction of a permeable soil cover, grading for stormwater collection over the entire site, and vegetation of the entire site. The vegetative cover would be designed to promote transpiration and limit erosion. Potential vegetation includes a mixture of warm- and cool-season native grasses, shrubs, and trees. As with the previous alternative, groundwater monitoring is a component of the O&M for Alternative 3.

ET cover systems use water balance components to minimize the downward migration of water from the cover to the waste (percolation), unlike conventional cover system designs that use materials with low hydraulic permeability (barrier layers) to minimize percolation. ET cover systems rely on the properties of soil to store water until it is either transpired through vegetation or evaporated from the soil surface. The ET cover system design would be based on water balance components specific to the site such as the water storage capacity of the soil, precipitation, surface runoff, evapotranspiration, and infiltration. For example, with greater storage capacity and evapotranspiration properties of the existing soil

at the site, there would be a lower potential for percolation through the cover system. Therefore, ET cover systems tend to highlight the following properties:

1. Fine-grained soils, such as silts and clayey silts, that have a relatively high water storage capacity;
2. Native vegetation to increase evapotranspiration; and
3. Locally available soils to streamline construction and provide cost savings.

Two general types of ET cover systems are monolithic barriers and capillary barriers. Monolithic covers use a single vegetated soil layer to retain water until it is transpired through vegetation or evaporated through the soil surface. A capillary barrier system consists of a finer-grained soil layer overlying a coarser-grained material layer, usually sand or gravel.

ET cover systems are increasingly being considered for use at municipal solid waste and hazardous waste landfills when equivalent performance to conventional final cover systems can be demonstrated. ET covers are generally less costly to construct and have the potential to provide equal or superior performance compared to conventional cover systems, especially in arid or semi-arid environments. The limitations of ET systems include the following:

1. Generally considered applicable only in arid or semi-arid climates;
2. Storage capacity must be relied on for large precipitation events occurring during dormant periods;
3. Production of landfill gases may limit plant growth;
4. Landfill gases are not normally captured and vented with ET cover systems;
5. Limited performance data are available; and
6. Models do not effectively predict performance of ET cover systems.

Site Preparation

Site preparation would be the same as detailed in Alternative 2.

Soil Cover and Vegetation

Following completion of site preparation, a grading layer would be constructed on the site using the IDOT material to attain the final site contour, demarcation fabric would be installed across the entire site, and a 4-foot-thick ET soil cap would be constructed. Perimeter waste may need to be excavated and consolidated on site to move it away from the site edges. As necessary, additional fill will be imported and placed to develop an acceptable degree of slope for proper drainage. The ET soil cap would consist of an uncompacted, medium-permeability soil, such a loam or sandy loam. Given the soil properties needed to facilitate proper root growth and permeability, the IDOT material could not be used. Therefore, materials associated with the construction of the ET soil layer would have to be purchased and imported to the site.

The site would be contoured in such a way that all precipitation would be held on site and allowed to infiltrate. Biosolids would be incorporated into the top 6 inches of soil cover to provide a vegetative layer. Figure 3-1 shows a plan view of the site following remedial action, and Figure 3-3 illustrates the proposed cross section for this alternative. A mixture of warm- and cool-season native grasses, shrubs, and trees would be used for vegetation of the site based on their root depth penetration, evapotranspiration rates, growth rates, low maintenance requirements, and compatibility with the end use for the site.

Effectiveness and Cost

The principal “functional” element of this alternative is the ET soil cap. The ET soil cover will minimize infiltration into the waste; therefore, the volume and rate of flow of contaminated groundwater will diminish somewhat. The alternative fails to address the collection and destruction of generated LFG. This alternative does not provide a great deal of flexibility with respect to future land uses, since any excavation or drilling would be prohibited from disturbing the soil cover. Most “surface only” land use would not be available because of ET cap vegetation.

The cost to construct Alternative 3 is estimated to be \$18,700,000, and yearly O&M will cost approximately \$65,000. Assuming 30 years of O&M will be required and an inflation rate of 5%, the net present worth of this alternative is estimated to be \$19,700,000. Table 3-2 summarizes the cost estimates for Alternative 3. Detailed cost estimate tables for each alternative are included in Appendix C.

3.4 Alternative 4: Capping of Existing Wastes with a Low-Permeability, 35 IAC Part 724 Clay Cap

Description of Remedial Alternative

Alternative 4 involves construction of a low-permeability clay cap over the existing wastes and the creation of an appropriate cap grade for stormwater runoff. This alternative involves construction of a low-permeability clay cap meeting the requirements of Title 35 IAC Part 724, grading for stormwater containment and collection over the entire site, construction of a stormwater retention pond with overflow to the Paxton I Landfill stormwater collection system, installation of a gas collection system, and vegetation of the entire site with native plants and prairie grasses. As with the previous alternatives, groundwater monitoring is a component of the O&M for this alternative.

Site Preparation

Site preparation would be the same as detailed in Alternative 2.

Gas Collection

To control LFG generation, a gas collection system would be installed across the entire site. The system would consist of horizontal collection pipes placed in excavated trenches. The trenches will be excavated into the existing soil cover to the top of the underlying waste layer. It has been estimated that trenching for the gas collection system would be completed at an average depth of 4 feet across the site based on data collected and observations made during trenching for previous site investigations. All trenched material would be disposed of by consolidation on site. It is anticipated that the trenches will be backfilled around perforated collection piping using a slag material imported to site. A geotextile would be placed between the slag and subsequent soil layers to prevent silt from entering the system.

Clay Cap and Vegetation

Following completion of the gas collection layer, a grading layer would be constructed on the site to attain the final site contour, and a low-permeability clay cap meeting the requirements of Title 35 IAC Part 724, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*, would be constructed. Perimeter waste may need to be excavated and consolidated on site to move it away from the site edges. As necessary, the IDOT material would be re-excavated and placed to develop an acceptable degree of slope for proper drainage across the entire site. The clay cap would consist of the IDOT material compacted to a thickness of 3 feet with a permeability of 1×10^{-7} cm/sec, overlain by a 1.5-foot uncompacted protective soil layer. A drainage collection and conveyance layer would be installed above the low-permeability layer consisting of a 200-mil geocomposite geonet, a 6-inch sand drainage layer, an 8-inch cobble drain biotic layer, and a geotextile filter fabric. The drainage layer would collect water that infiltrates through the protective cover soil, remove it from the surface of the low-permeability layer, and convey it to the stormwater drainage system.

Biosolids would be incorporated into the top 6 inches of the protective layer to provide a vegetative layer. Figure 3-1 shows a plan view of the site following remedial action, and Figure 3-4 illustrates the proposed cross section for this alternative. This remedial alternative results in steeper slopes on the site and lower-permeability surfaces. Runoff from precipitation events would be greater in total volume following low-permeability cap construction and would accumulate more rapidly than on the existing, poorly drained site.

In terms of water quality, the runoff from the cap will be considered uncontaminated, since it will not contact waste materials or contaminated media. To collect, and regulate the discharge rate of, stormwater from the site, a detention pond would be constructed. Runoff would flow overland as sheet flow toward the detention pond, with shallow swales along the site perimeter aiding in collecting

3. Development of Remedial Alternatives

Focused Feasibility Study Section No.: 3
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and transporting the flow to the pond. The pond area would be built above the soil cover and lined with a flexible membrane liner (FML, or 60-mil high-density polyethylene [HDPE]) with riprap protection at the waterline to protect the liner from ultraviolet exposure and to protect soil above the FML. A weir structure to regulate overflow and a discharge channel will also be included.

From the discharge, water would flow through the discharge channel to the Paxton I Landfill stormwater collection system. Water could be easily routed from the overflow weir to Indian Ridge Marsh, which presently receives LCC site runoff. A new culvert would be jacked or directionally bored under the Norfolk Southern railroad tracks for this purpose if the existing culverts prove unsuitable for this use. Native short-rooted prairie grasses would be used for vegetation of the site based on their low maintenance requirements and compatibility with the end use of the site.

Effectiveness and Cost

The four principal “functional” elements of this alternative are the compacted low-permeability clay cap, gas collection layer, drainage layer, and stormwater management system. The clay cap would substantially reduce precipitation infiltration into the waste (because of the improved slope for more rapid, positive drainage). The volume and rate of flow of contaminated groundwater would diminish. Disadvantages of the stormwater management system are related to the relatively shallow depth to the remaining waste on site, reduced flexibility for future use, and the relatively large volumes of fill soils required from off-site sources to shape and contour the site for proper drainage. The top of the cover would be a minimum of 5 feet 8 inches above the remaining waste, with the average depth greater over most of the site area. This separation from the waste provides reduced contact potential with the remaining waste materials. It does not provide a great deal of flexibility with respect to future land uses, since any excavation or drilling activities would be prohibited from disturbing the soil cover. Almost any “surface only” land use could be accommodated under this alternative.

As with all the capping alternatives, stormwater runoff will increase with a low-permeability cap with a positive degree of slope. However, the stormwater would also be clean and free of contamination since it would not be in contact with the waste materials. Modeling and calculating the flow volumes would be an integral part of designing the soil cover. The general surface elevation of the site would be raised by construction, which necessitates the creation of berms around the perimeters to collect and control stormwater runoff and prevent it from flowing off site.

The cost to construct Alternative 4 is estimated to be \$17,700,000, and yearly O&M will cost approximately \$83,000. Assuming 30 years of O&M will be

required and an inflation rate of 5%, the net present worth of this alternative is estimated to be \$18,900,000. Table 3-3 summarizes the cost estimate for Alternative 4. Detailed cost estimate tables for each alternative are included in Appendix C.

3.5 Alternative 5: Capping of Existing Wastes with a Low-Permeability 35 IAC Part 811 Clay Cap

Description of Remedial Alternative

Alternative 5 involves construction of a low-permeability clay cap over the existing wastes and creation of an appropriate grade for stormwater runoff from the cap. This alternative involves construction of a low-permeability clay cap meeting the requirements of Title 35 IAC Part 811, grading for stormwater containment and collection over the entire site, construction of a stormwater retention pond with overflow to the Paxton I Landfill stormwater collection system, and vegetation of the entire site with native plants and prairie grasses. As with all of the previous remedial action alternatives, O&M for Alternative 5 includes groundwater monitoring.

Site Preparation

Site preparation would be the same as detailed in Alternative 2.

Gas Collection

Gas collection would be the same as detailed in Alternative 4.

Clay Cap and Vegetation

Following installation of the gas collection layer, a grading layer would be constructed on the site to attain the final site contour, and a low-permeability clay cap meeting the requirements of Title 35 IAC Part 811, *Standards for New Solid Waste Landfills*, would be built. Perimeter waste may need to be excavated and consolidated on site to move it away from the site boundaries. As necessary, IDOT material will be re-excavated and placed atop the grading to develop an acceptable degree of slope for proper drainage across the entire site. Using IDOT soils, the cap will consist of compacted clay, 3 feet thick, having a permeability of 1×10^{-7} cm/sec, overlain by a 3-foot uncompacted protective soil layer. Biosolids will be incorporated into the top 6 inches of the protective layer to provide a vegetative layer. Figure 3-1 shows a plan view of the site following remedial action. Figure 3-5 illustrates the proposed cross section for this alternative.

This remedial alternative results in steeper slopes on the site and lower-permeability surfaces. Runoff from precipitation events would be greater in total volume following low-permeability cap construction and will accumulate more rapidly than on the existing site. In terms of water quality, the runoff from the cap

will be considered uncontaminated, since it will not contact waste materials or contaminated media.

To collect and regulate the discharge rate of stormwater from the site, a detention pond would be constructed. Runoff would flow overland as sheet flow toward the detention pond, with shallow swales along the site perimeters aiding in collecting and transporting the flow to the pond. The pond area would be built above the soil cover and have an FML (60-mil HDPE) with riprap protection at the waterline to protect the liner from ultraviolet exposure and to protect soil above the FML. A weir structure to regulate overflow and a discharge channel would also be included.

From the discharge, water would flow through the discharge channel to the Paxton I Landfill stormwater collection system. Water could be easily routed from the overflow weir to Indian Ridge Marsh, which presently receives LCC site runoff. A new culvert would be jacked or directionally bored under the Norfolk Southern railroad tracks for this purpose if the existing culverts prove unsuitable for use. Native short-rooted prairie grasses would be used for vegetation of the site based on their low maintenance requirements and compatibility with the end use for the site.

Effectiveness and Cost

The three principal “functional” elements of this alternative are the compacted low-permeability clay cap, gas collection layer, and the stormwater management system. The clay cap will substantially reduce precipitation infiltration into the waste (because of the improved slope for more rapid, positive drainage). The volume and rate of flow of contaminated groundwater will decrease. Disadvantages of the stormwater management system are related to the relatively shallow depth to remaining waste on site, reduced flexibility for future site use, and the relatively large volumes of fill soils required from off-site sources to shape and contour the site for proper drainage.

The cost to construct Alternative 5 is estimated to be \$15,900,000, and yearly O&M will cost approximately \$83,000. Assuming 30 years of O&M will be required and an inflation rate of 5%, the net present worth of this alternative is estimated to be \$17,200,000. Table 3-4 summarizes the cost estimates for the remedial alternatives. Detailed cost estimate tables for each alternative are included in Appendix C.

3. Development of Remedial Alternatives

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Table 3-1 Preliminary Construction Cost Estimate, Alternative 2 - Capping of Existing Wastes with a Permeable Soil Cover
Focused Feasibility Study, Lake Calumet Cluster Site,
Chicago, Cook County, Illinois

Item	Description	Quantity	Unit	Cost
Direct Capital Costs				
C1a	Field Overhead and Oversight	0.5	LS	\$ 737,100
C1b	Submittals and Testing	0.75	LS	\$ 75,000
C1c.1	Pre-Construction Surveying	1	LS	\$ 22,000
C1c.2	Construction Surveying	0.5	LS	\$ 254,800
C1c.3	Post-Construction Surveying	1	LS	\$ 22,000
C2a	Clearing and Grubbing	1	LS	\$ 18,100
C2b	Demolition	1	LS	\$ 50,000
C2c	Relocate Utilities	1	LS	\$ 100,000
C4a	Grading Layer (~2.5' thick)	346,000	CY	\$ 2,322,200
C4b	Permeable Soil Layer (2' Thick)	290,667	CY	\$ 5,051,900
C5b	Biosolids, tilled 6" deep into cover	3,920	MSF	\$ 11,200
C5c	Seeding	90	Acre	\$ 126,000
C5d	Fence	7,200	LF	\$ 95,990
Total Direct Capital Costs (Rounded to Nearest \$1,000)				\$ 8,886,000
Indirect Capital Costs				
	Engineering and Design	5%		\$ 399,870
	Legal Fees and License/Permit Costs	3%		\$ 222,150
	Construction Oversight	5%		\$ 399,870
Total Indirect Capital Costs (Rounded to Nearest \$1,000)				\$ 1,022,000
Total Capital Costs				
	Subtotal Capital Costs			\$ 9,908,000
	Contingency Allowance	10%		\$ 990,800
Total Capital Cost (Rounded to Nearest \$1,000)				\$ 10,899,000
Item	Description	Quantity	Unit	Cost
Annual Direct O&M Costs				
O2a	Annual Groundwater Monitoring	16	Each	\$ 15,700
O3a	Cover Inspection	1	LS	\$ 4,400
O3b	Cover Maintenance	1	LS	\$ 10,500
O3d	Access Road Maintenance	1	LS	\$ 15,000
O3e	Annual Summary Report	1	LS	\$ 2,600
Total Annual Direct O&M Costs (Rounded to Nearest \$1,000)				\$ 48,000
Annual Indirect O&M Costs				
	Administration	5%		\$ 2,400
	Insurance, Taxes, Licenses	3%		\$ 1,200
Total Annual Indirect O&M Costs (Rounded to Nearest \$1,000)				\$ 4,000
Total Annual O&M Costs				
	Subtotal Annual O&M Costs			\$ 52,000
	Contingency Allowance	25%		\$ 13,000
Total Annual O&M Cost (Rounded to Nearest \$1,000)				\$ 65,000
30 Year Cost Projection (Assume discount Rate per year: 5%)				
Total Capital Costs				\$ 10,899,000
Present Worth of 30 Years O&M (Rounded to Nearest \$1,000)				\$ 999,000
Total Cost: Alternative 2 (Rounded to nearest \$10,000)				\$ 11,900,000

Key:

LS = Lump sum.

O & M = Operations and maintenance.

CY = Cubic Yard.

MSF = Million square feet.

3. Development of Remedial Alternatives

Focused Feasibility Study Section No.: 3

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Date: June 2006

**Table 3-2 Preliminary Construction Cost Estimate, Alternative 3 - Capping of Existing Wastes with an Evapotranspiration (ET) Cap
Focused Feasibility Study, Lake Calumet Cluster Site
Chicago, Cook County, Illinois**

Item	Description	Quantity	Unit	Cost
Direct Capital Costs				
C1a	Field Overhead and Oversight	1	LS	\$ 1,474,200
C1b	Submittals and Testing	1	LS	\$ 100,000
C1c	Surveying	1	LS	\$ 553,600
C2a	Clearing and Grubbing	1	Acre	\$ 18,100
C2b	Demolition	1	LS	\$ 50,000
C2c	Relocate Utilities	1	LS	\$ 100,000
C4a	Grading Layer (~2.5' thick)	346,000	CY	\$ 2,322,200
C4h	Demarcation Fabric Installation	436,000	SY	\$ 270,300
C4j	Soil (Silty Loam) Layer (4' thick)	581,333	CY	\$ 9,600,000
C4k	ET Vegetation	90	Acre	\$ 674,700
C5b	Biosolids, tilled 6" deep into cover	3,920	MSF	\$ 11,200
C5d	Fence	7,200	LF	\$ 95,990
Total Direct Capital Costs (Rounded to Nearest \$1,000)				\$ 15,270,000
Indirect Capital Costs				
	Engineering and Design	5%		\$ 687,150
	Legal Fees and License/Permit Costs	3%		\$ 381,750
	Construction Oversight	5%		\$ 687,150
Total Indirect Capital Costs (Rounded to Nearest \$1,000)				\$ 1,756,000
Total Capital Costs				
	Subtotal Capital Costs			\$ 17,026,000
	Contingency Allowance	10%		\$ 1,702,600
Total Capital Cost (Rounded to Nearest \$1,000)				\$ 18,729,000
Annual Direct O&M Costs				
Item	Description	Quantity	Unit	Cost
O2a	Annual Groundwater Monitoring	16	Each	\$ 15,700
O3a	Cover Inspection	1	LS	\$ 4,400
O3b	Cover Maintenance	1	LS	\$ 10,500
O3d	Access Road Maintenance	1	LS	\$ 15,000
O3e	Annual Summary Report	1	LS	\$ 2,600
Total Annual Direct O&M Costs (Rounded to Nearest \$1,000)				\$ 48,000
Annual Indirect O&M Costs				
	Administration	5%		\$ 2,400
	Insurance, Taxes, Licenses	3%		\$ 1,200
Total Annual Indirect O&M Costs (Rounded to Nearest \$1,000)				\$ 4,000
Total Annual O&M Costs				
	Subtotal Annual O&M Costs			\$ 52,000
	Contingency Allowance	25%		\$ 13,000
Total Annual O&M Cost (Rounded to Nearest \$1,000)				\$ 65,000

30 Year Cost Projection (Assume discount Rate per year: 5%)	
Total Capital Costs	\$ 18,729,000
Present Worth of 30 Years O&M (Rounded to Nearest \$1,000)	\$ 999,000
Total Cost: Alternative 3 (Rounded to nearest \$10,000)	\$ 19,730,000

Key:

LS = Lump sum.

MSF = Million square feet.

O & M = Operations and maintenance.

SY = Square Yard.

CY = Cubic Yard.

**3. Development of Remedial Alternatives**

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Date: June 2006

Table 3-3 Preliminary Construction Cost Estimate, Alternative 4 - Capping of Existing Wastes with a Low-Permeability 35 IAC 724 Clay Clap
Focused Feasibility Study, Lake Calumet Cluster Site
Chicago, Cook County, Illinois

Item	Description	Quantity	Unit	Cost
Direct Capital Costs				
C1a	Field Overhead and Oversight	1	LS	\$ 1,474,200
C1b	Submittals and Testing	1	LS	\$ 100,000
C1c	Surveying	1	LS	\$ 553,600
C2a	Cleaning and Grubbing	1	Acre	\$ 18,100
C2b	Demolition	1	LS	\$ 50,000
C2c	Relocate Utilities	1	LS	\$ 100,000
C3a	Trenching (4' Depth)	42,000	CY	\$ 224,206
C3b	Collection Pipe	94,000	LF	\$ 645,337
C3c	Trench Infill	42,000	CY	\$ 76,987
C3d	Geotextile	52,000	SY	\$ 98,203
C4a	Grading Layer	346,000	CY	\$ 2,322,200
C4c	Impervious Layer (3' Thick)	436,000	CY	\$ 3,054,900
C4d	Geonet	3,924,000	SF	\$ 1,569,600
C4e	Sand Drainage Layer (6" Thick)	73,000	CY	\$ 1,057,500
C4f	Cobble Drain-Biotic Layer (8" Thick)	97,000	CY	\$ 405,500
C4g	Geotextile	436,000	SY	\$ 392,400
C4i	Cover Layer (1.5' Thick)	218,000	CY	\$ 1,717,600
C5a	Drain Layer Collection/Conveyance	Job	LS	\$ 335,000
C5b	Biosolids, tilled 6" deep into cover	3,920	MSF	\$ 11,200
C5c	Seeding	90	Acre	\$ 126,000
C5d	Fence	7,200	LF	\$ 95,990
Total Direct Capital Costs (Rounded to Nearest \$1,000)				\$ 14,429,000
Indirect Capital Costs				
	Engineering and Design	5%		\$ 649,305
	Legal Fees and License/Permit Costs	3%		\$ 360,725
	Construction Oversight	5%		\$ 649,305
Total Indirect Capital Costs (Rounded to Nearest \$1,000)				\$ 1,659,000
Total Capital Costs				
	Subtotal Capital Costs			\$ 16,088,000
	Contingency Allowance	10%		\$ 1,608,800
Total Capital Cost (Rounded to Nearest \$1,000)				\$ 17,697,000
Item	Description	Quantity	Unit	Cost
Annual Direct O&M Costs				
O1a	Gas Collection Condensate Disposal	16	Hour	\$ 1,900
O2a	Annual Groundwater Monitoring	16	Each	\$ 15,700
O3a	Cover Inspection	1	LS	\$ 4,400
O3b	Cover Maintenance	1	LS	\$ 10,500
O3c	Vent System Monitoring and Maintenance	1	LS	\$ 11,300
O3d	Access Road Maintenance	1	LS	\$ 15,000
O3e	Annual Summary Report	1	LS	\$ 2,600
Total Annual Direct O&M Costs (Rounded to Nearest \$1,000)				\$ 61,000
Annual Indirect O&M Costs				
	Administration	5%		\$ 3,050
	Insurance, Taxes, Licenses	3%		\$ 1,525
Total Annual Indirect O&M Costs (Rounded to Nearest \$1,000)				\$ 5,000
Total Annual O&M Costs				
	Subtotal Annual O&M Costs			\$ 66,000
	Contingency Allowance	25%		\$ 16,500
Total Annual O&M Cost (Rounded to Nearest \$1,000)				\$ 83,000
30 Year Cost Projection (Assume discount Rate per year: 5%)				
Total Capital Costs				\$ 17,697,000
Present Worth of 30 Years O&M (Rounded to Nearest \$1,000)				\$ 1,276,000
Total Cost: Alternative 4 (Rounded to nearest \$10,000)				\$ 18,970,000

Key:

LS = Lump sum.

CY = Cubic Yard.

MSF = Million square feet.

O & M = Operations and maintenance.

LF = Linear foot.

SF = Square foot.

**3. Development of Remedial Alternatives**

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Table 3-4

Preliminary Construction Cost Estimate, Alternative 5 - Capping of Existing Wastes with a Low-Permeability 35 IAC 811 Clay Clap
Focused Feasibility Study, Lake Calumet Cluster Site
Chicago, Cook County, Illinois

Item	Description	Quantity	Unit	Cost
Direct Capital Costs				
C1a	Field Overhead and Oversight	1	LS	\$ 1,474,200
C1b	Submittals and Testing	1	LS	\$ 100,000
C1c	Surveying	1	LS	\$ 553,600
C2a	Clearing and Grubbing	1	Acre	\$ 18,100
C2b	Demolition	1	LS	\$ 50,000
C2c	Relocate Utilities	1	LS	\$ 100,000
C3a	Trenching (4' Depth)	42,000	CY	\$ 224,206
C3b	Collection Pipe	94,000	LF	\$ 645,337
C3c	Trench Infill	42,000	CY	\$ 645,337
C3d	Geotextile	52,000	SY	\$ 98,203
C4a	Grading Layer (~2.5' thick)	346,000	CY	\$ 2,322,200
C4c	Impervious Layer (3' thick)	436,000	CY	\$ 3,054,900
C4i	Cover Layer (3' Thick)	436,000	CY	\$ 3,435,200
C5b	Biosolids, tilled 6" deep into cover	3,920	MSF	\$ 11,200
C5c	Seeding	90	Acre	\$ 126,000
C5d	Fence	7,200	LF	\$ 95,990
Total Direct Capital Costs (Rounded to Nearest \$1,000)				\$ 12,954,000
Indirect Capital Costs				
	Engineering and Design	5%		\$ 582,930
	Legal Fees and License/Permit Costs	3%		\$ 323,850
	Construction Oversight	5%		\$ 582,930
Total Indirect Capital Costs (Rounded to Nearest \$1,000)				\$ 1,490,000
Total Capital Costs				
	Subtotal Capital Costs			\$ 14,444,000
	Contingency Allowance	10%		\$ 1,444,400
Total Capital Cost (Rounded to Nearest \$1,000)				\$ 15,888,000
Item	Description	Quantity	Unit	Cost
Annual Direct O&M Costs				
O1a	Gas Collection Condensate Disposal	0	0	\$ 1,900
O2a	Annual Groundwater Monitoring	16	Each	\$ 15,700
O3a	Cover Inspection	1	LS	\$ 4,400
O3b	Cover Maintenance	1	LS	\$ 10,500
O3c	Vent System Monitoring and Maintenance	1	LS	\$ 11,300
O3d	Access Road Maintenance	1	LS	\$ 15,000
O3e	Annual Summary Report	1	LS	\$ 2,600
Total Annual Direct O&M Costs (Rounded to Nearest \$1,000)				\$ 61,000
Annual Indirect O&M Costs				
	Administration	5%		\$ 3,050
	Insurance, Taxes, Licenses	3%		\$ 1,525
Total Annual Indirect O&M Costs (Rounded to Nearest \$1,000)				\$ 5,000
Total Annual O&M Costs				
	Subtotal Annual O&M Costs			\$ 66,000
	Contingency Allowance	25%		\$ 16,500
Total Annual O&M Cost (Rounded to Nearest \$1,000)				\$ 83,000
30 Year Cost Projection (Assume discount Rate per year: 5%)				
Total Capital Costs				\$ 15,888,000
Present Worth of 30 Years O&M (Rounded to Nearest \$1,000)				\$ 1,276,000
Total Cost: Alternative 5 (Rounded to nearest \$10,000)				\$ 17,160,000

Key:

LS = Lump sum.

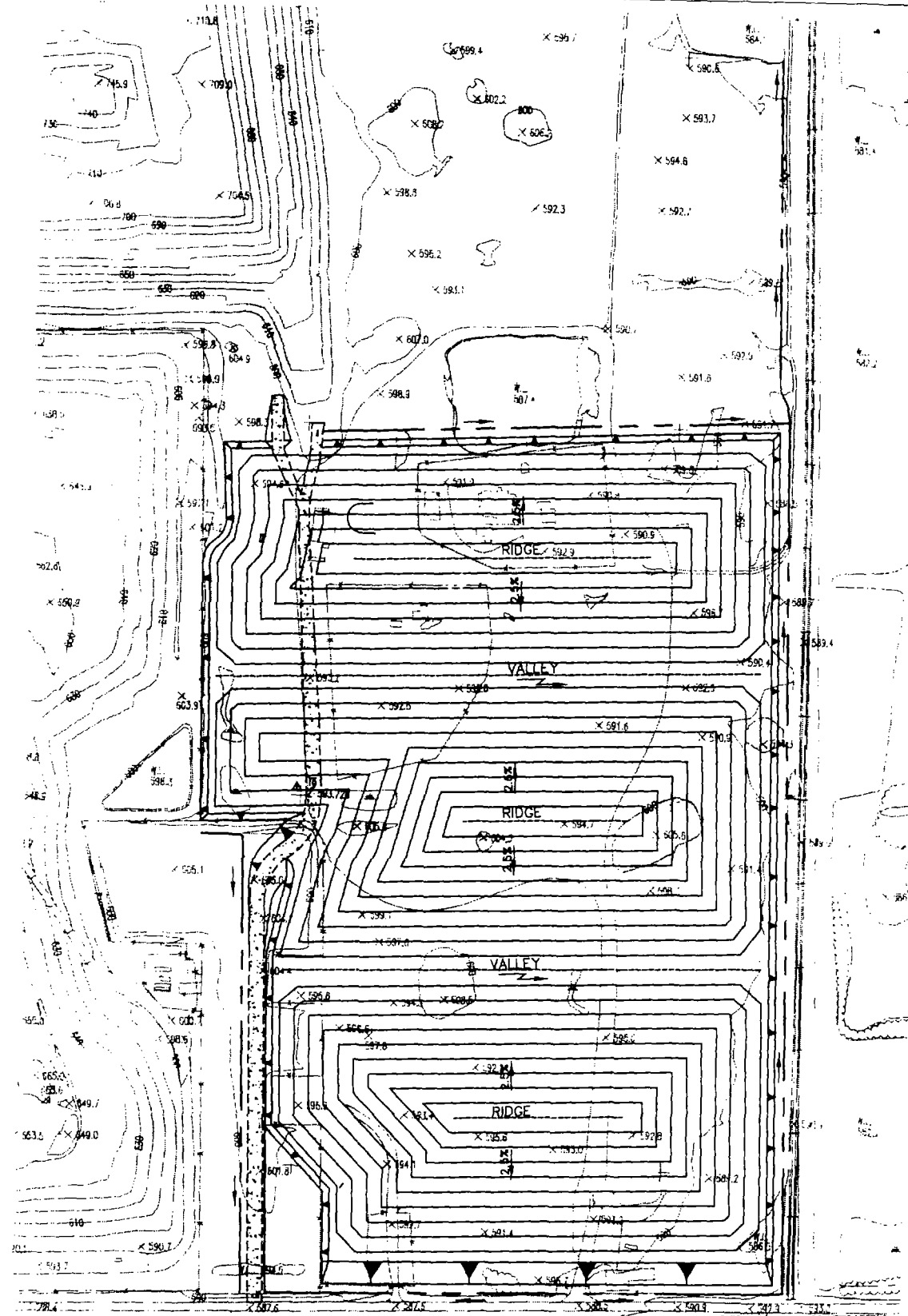
MSF = Million square feet.

O & M = Operations and maintenance.

CY = Cubic Yard.

LF = Linear foot.

SY = Square Yard.



LEGEND

- 2.5% GRADE ON FINISHED SLOPE
- FINISHED SLOPE APPROXIMATELY 1V ON 3H EXCEPT AS NOTED
- IMPROVED DRAINAGE DITCH ADJACENT TO FINISHED SLOPES
- DIRECTION OF DRAINAGE ON CAP
- ACCESS ROAD

NOTE:
CAP AS SHOWN DRAINS RUNOFF AWAY FROM CAP



ecology and environment, inc.
International Specialists in the Environment
Portland, Oregon

DESIGNED BY: C. HANCAWORTH

CHECKED BY: A. WHITMAN

DRAWN BY: S. STEVENS

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

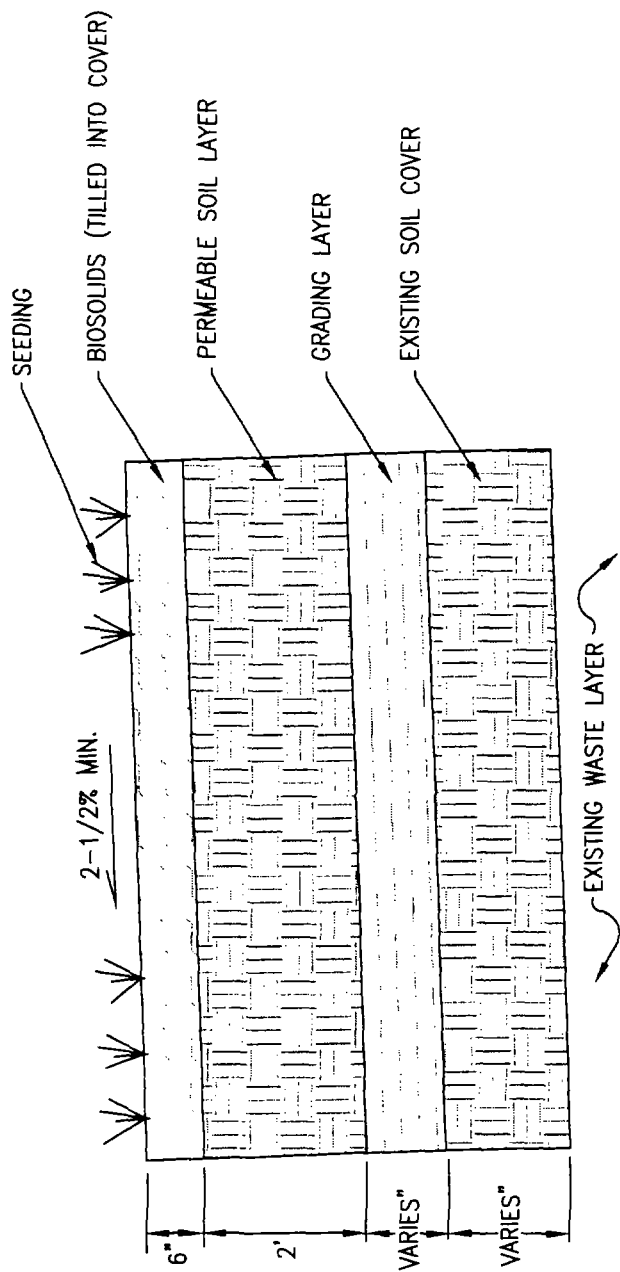
FIGURE 3-1
CONCEPTUAL DESIGN PLAN

CALUMET CLUSTER SITE
CHICAGO, ILLINOIS

SCALE
1"=400'

DATE DESIGNED
3-30-06

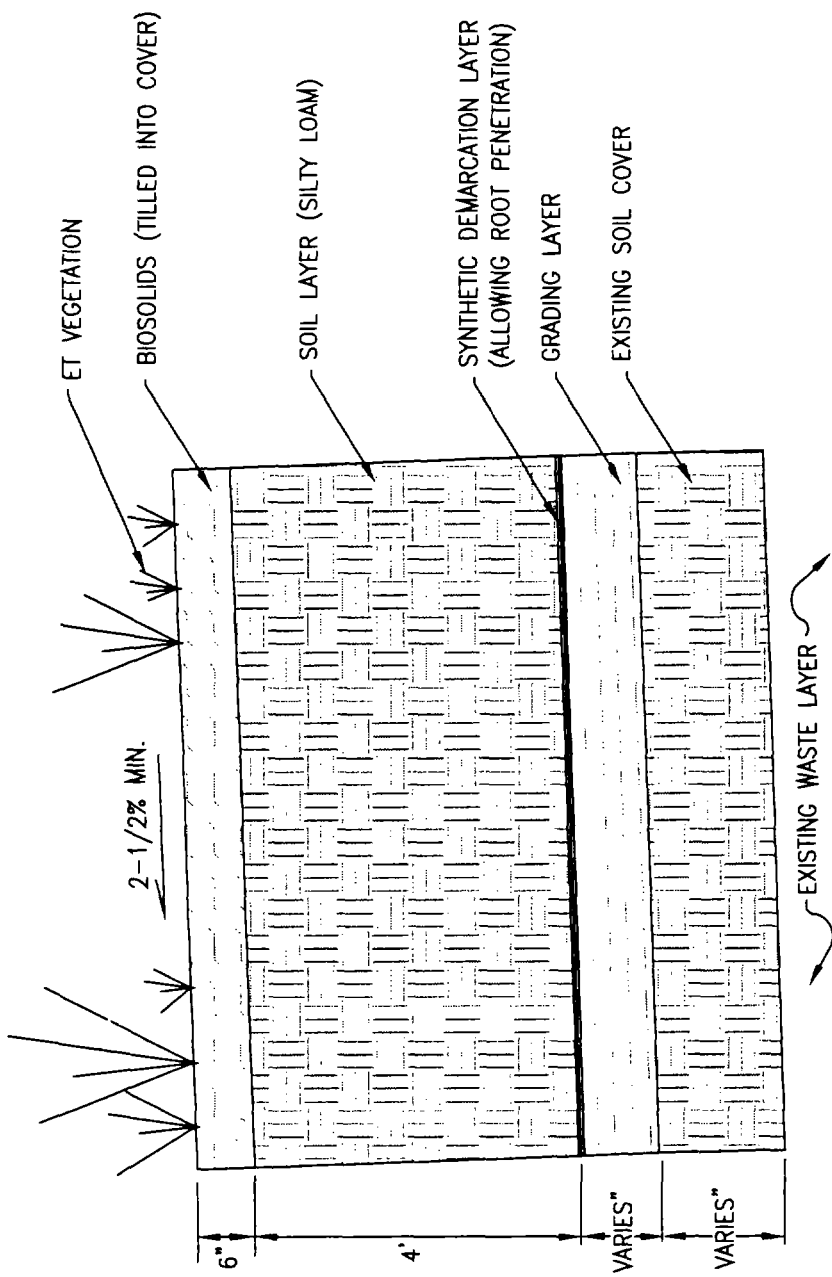
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PERMEABLE COVER SECTION (TYP.)


NTS

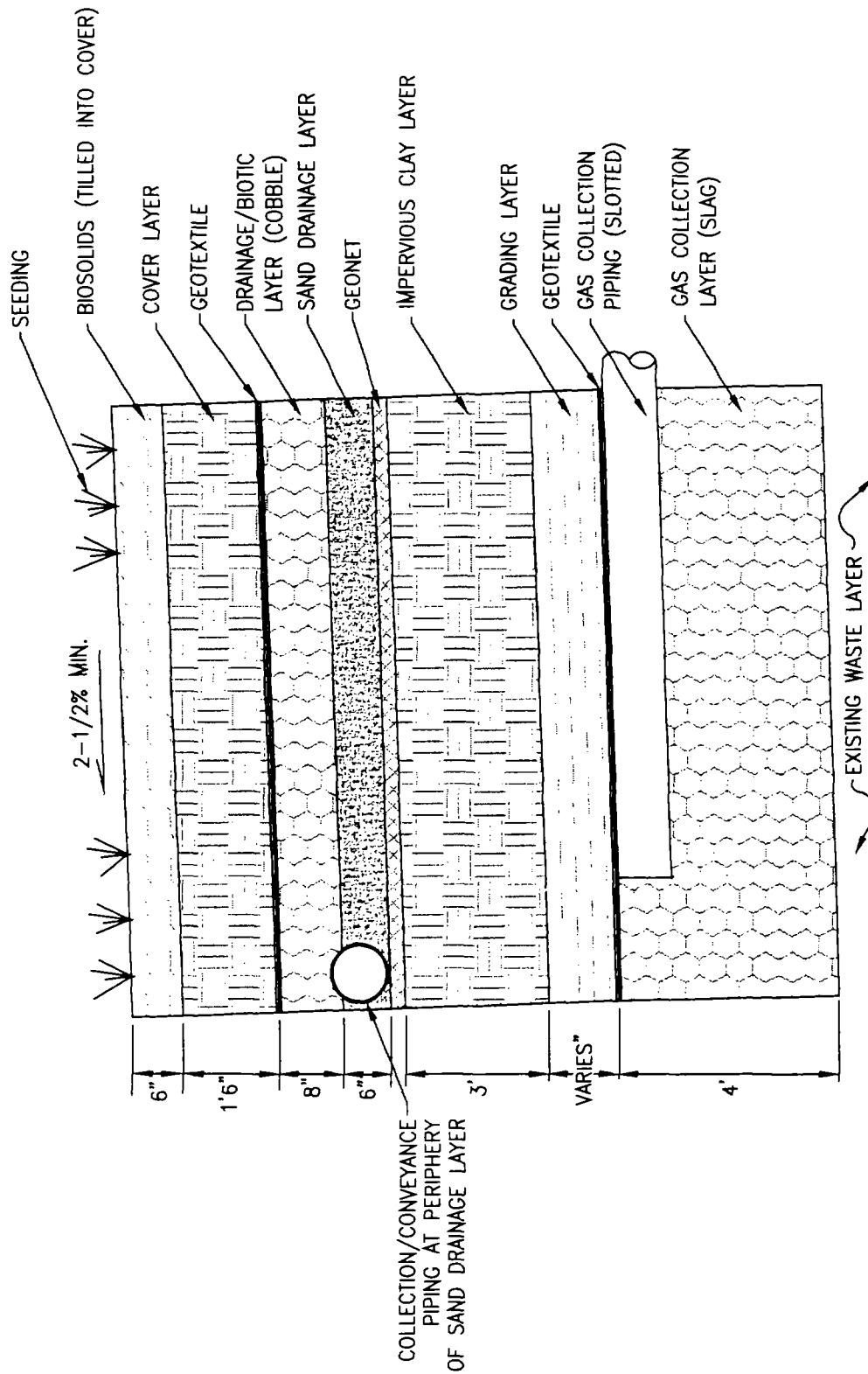
		ILLINOIS ENVIRONMENTAL PROTECTION AGENCY	
DESIGNED BY: T. CAMPBELL		FIGURE 3-2	
CHECKED BY: M. BROWN		PERMEABLE SOIL COVER SECTION	
DRAWN BY: T. CAMPBELL		LAKE CALUMET CLUSTER SITE CHICAGO, COOK COUNTY, ILLINOIS	
SCALE NONE	DATE REVISED 3/30/06	C.A.D. FILE NO.	PERMEABLE COVER SECTION.DWG



EVAPOTRANSPIRATION CAP SECTION (TYP.)

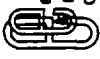
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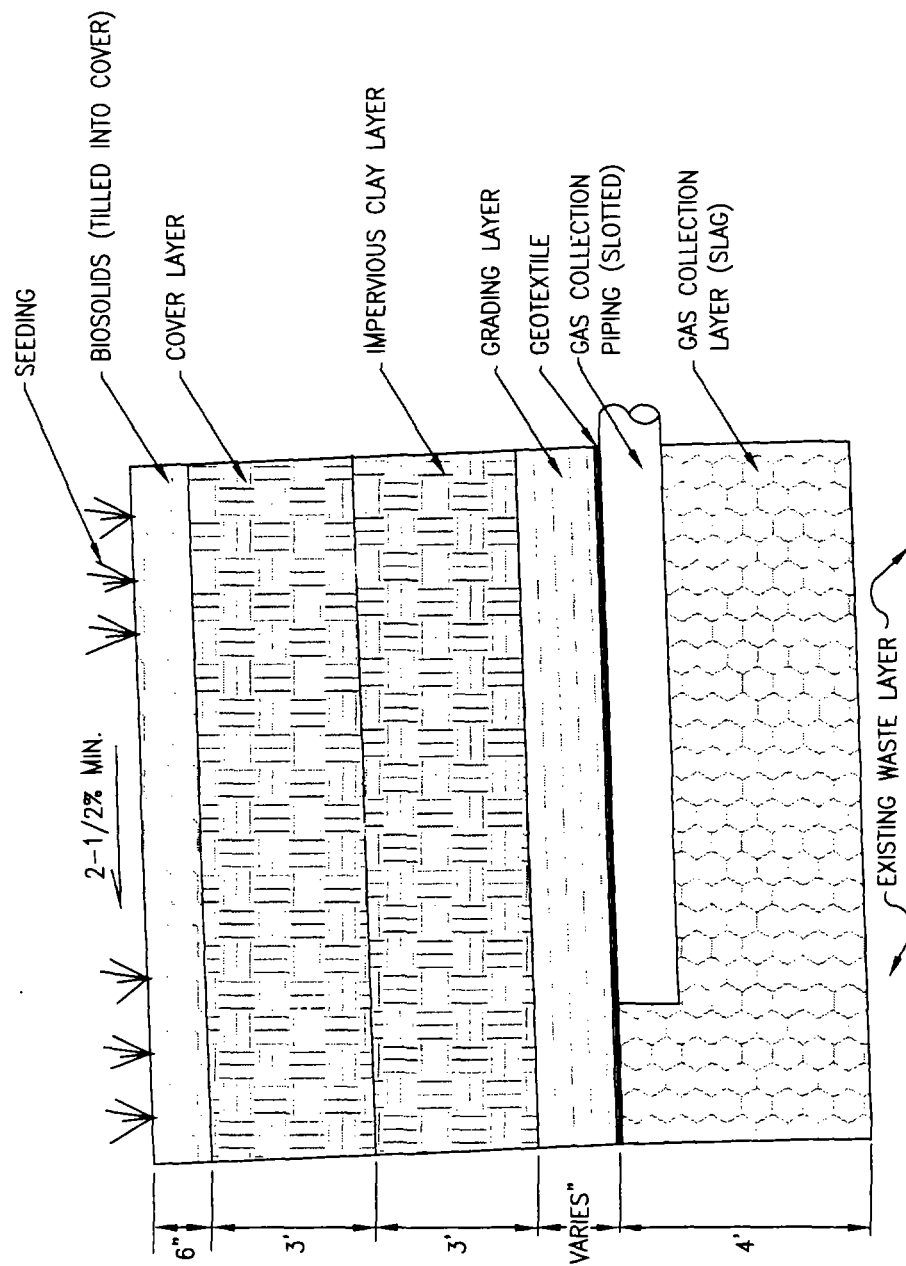
 Ecology and environmental engineering, Inc. International Specialists in the Environment Chicago, Illinois		ILLINOIS ENVIRONMENTAL PROTECTION AGENCY			
DESIGNED BY: T. CAMPBELL		FIGURE 3-3 EVAPOTRANSPIRATION (ET) CAP SECTION LAKE CALUMET CLUSTER SITE CHICAGO, COOK COUNTY, ILLINOIS			
CHECKED BY: M. BROWN					
DRAWN BY: T. CAMPBELL					
SCALE NONE	DATE REVISION 3/30/06	SCALE NONE		DATE REVISION 3/30/06	



724 CAP SECTION ABOVE GAS COLLECTION LATERAL (TYP.)

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DESIGNED BY: C. NANCARROW/T. CAMPBELL CHECKED BY: N. BROWN DRAWN BY: S. STEVENS/T. CAMPBELL		FIGURE 3-4 LOW-PERMEABLE 35 IAC PART 724 CLAY CAP SECTION LAKE CALUMET CLUSTER SITE CHICAGO, COOK COUNTY, ILLINOIS	
SCALE: NONE DATE REVISION: 3/30/06 CLASS. FILE NO.: 724 CAP SECTION.DWG			



811 CAP SECTION ABOVE GAS COLLECTION LATERAL (TYP.)

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ecology and environment engineering, inc. International Specialists in the Environment Chicago, Illinois		ILLINOIS ENVIRONMENTAL PROTECTION AGENCY	
DESIGNED BY: T. CAMPBELL		FIGURE 3-5	
CHECKED BY: N. BROWN		LOW-PERMEABLE 35 IAC PART 811 CLAY CAP SECTION	
DRAWN BY: T. CAMPBELL		LAKE CALUMET CLUSTER SITE CHICAGO, COOK COUNTY, ILLINOIS	
		SCALE: NONE	DATE: 3/30/06
			C.A.B. FILE NO. 811 CAP SECTION.DWG

4

Detailed Analysis of Alternatives

The detailed analysis of alternatives is intended to provide the relevant information required to select a remedy. The evaluation of alternatives was conducted using EPA's nine primary evaluation criteria, which are listed in Section 300.430 in Paragraph (e) (9) (iii) of the NCP. These criteria are:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Short-term impacts and effectiveness;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume;
- Implementability;
- Cost;
- State acceptance; and
- Public acceptance.

It should be noted that the final two criteria (State and Community Acceptance) are used to modify the selection of an alternative. These criteria will be assessed after the public comment period that follows issuance of the Proposed Plan (the precursor to the IROD). Therefore, these two criteria will not be used in the evaluation presented in this report.

The remaining seven evaluation criteria will be used as the basis of the detailed analysis, which will provide in-depth information that can be used in selecting an interim remedial action alternative for implementation. Descriptions of each of the evaluation criteria are provided below:

Overall Protection of Human Health and the Environment – This criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The assessment of overall protection draws on the evaluation of the other criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.



Evaluation of the overall protectiveness of an alternative will focus on whether a specific alternative achieves adequate protection and will describe how site risks posed through each pathway being addressed by the FFS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. This evaluation will allow for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

Compliance with ARARs – This criterion will be used to determine whether each alternative will meet the identified ARARs. The detailed analysis will summarize which requirements are applicable, relevant, and appropriate to an alternative and describe how the alternative meets these requirements.

Short-Term Impacts and Effectiveness – This criterion will evaluate the effects that the alternative will have on human health and the environment during its construction and implementation phase.

Long-Term Effectiveness and Permanence – This criterion evaluates results of the interim remedial action in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation will be the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes remaining at the site.

Reduction of Toxicity, Mobility, or Volume – This criterion addresses the regulatory preference for selecting removal or remedial actions that employ treatment technologies permanently and significantly reducing the toxicity, mobility, or volume of the contaminants.

Implementability – This criterion evaluates the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required to construct and provide O&M.

Cost – Each alternative will have a detailed cost estimate prepared. The estimate will include:

- Estimation of capital and O&M costs; and
- Present worth analysis.

Costs developed as part of the FFS are expected to provide an accuracy of +/- 30%.

In Section 4.1, the alternatives are evaluated individually using the above-referenced criteria. A summary of the individual analyses is presented in Table 4-1. In Section 4.2, a comparative analysis of the alternatives (e.g., Alternative 1

versus Alternative 2) is performed to show how the alternatives rate when compared to each other and to the evaluation criteria, and a summary of the evaluation is presented in Table 4-2.

4.1 Individual Comparative Analysis

4.1.1 Alternative 1: No Action

Under this alternative, no remedial action would be undertaken at the LCC site. The site would remain in its current condition with the existing soil cover thickness of 0 to 3 feet.

Alternative 1 provides no protection of human health or the environment, and ARARs would not be met. *Since no construction activities would be performed, this alternative provides no adverse impacts in the short term.*

With regard to long-term effectiveness and permanence, Alternative 1 provides none, in that no remedial action would be implemented. Additionally, there is no reduction of toxicity, mobility, or volume. Potentially contaminated surface water runoff would continue to migrate into Indian Ridge Marsh, and infiltrate into the buried waste causing the contaminants to continue to leach into the groundwater.

The No Action alternative is readily implementable in that nothing is required to be constructed, maintained, or monitored. There are no costs associated with this alternative.

4.1.2 Alternative 2: Capping of Existing Wastes with a Permeable Soil Cover

Under this alternative, construction of a permeable soil cover, grading for stormwater collection over the entire site, and vegetation of the entire site with native plants and prairie grasses would be undertaken.

Alternative 2 provides limited protection of human health and the environment. The permeable soil cover would reduce the risk associated with direct human exposure to the buried waste material. However, surface water infiltration into the waste would still occur, resulting in further contaminant migration into the groundwater. Additionally, animals would still be able to burrow through the cover and enter into the waste.

This alternative would not meet most of the ARARs. Under 35 IAC 742.1105, a low-permeability cover is required for soils having contaminant concentrations that exceed the soil component of groundwater ingestion exposure route. Based on the analytical results from the previous site investigations, the contaminant concentrations detected at the LCC site exceed this threshold. The completed soil cover and topsoil vegetative layer would not eliminate exposure routes to ecological receptors (i.e., burrowing animals) using the site as a food/habitat

source. It is assumed that all location-specific ARARs (location near endangered species, wetlands, and secondary contact and indigenous aquatic life waters) would be waived since removal of waste materials is cost prohibitive. Action-specific ARARs for Illinois Pollution Control Board cover requirements (35 IAC 724, 811, and 817) would not be met by a permeable cap.

There are considerable short-term impacts associated with this alternative, which include road closures/restrictions, street cleaning activities, and control of fugitive dust and debris. This alternative does provide some long-term effectiveness and permanence in that human exposure to the buried waste would be reduced. However, animals may still be able to burrow into the waste.

Under this alternative, there would not be a significant reduction of toxicity, mobility, or volume; however, the soil cover would afford some protection from direct contact exposure to waste. The permeability of the cover would allow continued infiltration of precipitation, which would not reduce the migration of contaminants from the site. A disadvantage to the design is that prairie grass vegetation creates an "attractive nuisance" for birds and mammals; furthermore, burrowing animals can easily breach the cover. Implementing the alternative is simple and the design allows for future repairs to the cover to be easily made. Local tradesmen would be available to repair most conditions that may affect cover effectiveness.

4.1.3 Alternative 3: Capping of Existing Wastes with an Evapotranspiration (ET) Cap

Alternative 3 involves construction of an ET cap over the existing waste, which entails construction of a permeable soil cover, grading for stormwater collection, and vegetation with a mixture of warm- and cool-season native grasses, shrubs, and trees over the entire site to prevent infiltration and promote evapotranspiration.

4.1.3.1 Evaluation

Alternative 3 provides protection of human health and seasonal protection to the environment. The ET cap would prevent direct human exposure to the buried waste and would limit the amount of surface water infiltrating into the waste material. However, during periods of dormant plant growth, surface water would migrate into the waste and leach contaminants into the groundwater.

Under 35 IAC 742.1105, a low-permeability cover is required for soils having contaminant concentrations that exceed the soil component of groundwater ingestion exposure route. Based on the analytical results from the previous site investigations, the detected contaminant concentrations at the LCC site exceed this threshold. Additionally, 35 IAC 742.1105 requires a minimum of 10 feet of cover material to provide protection associated with the inhalation exposure

pathway. As proposed, Alternative 3 would not meet this ARAR. During vegetative growth seasons, the ET cap can significantly reduce surface water infiltration. However, during dormant growth periods, infiltration would occur unabated. A special waiver from the State of Illinois would have to be obtained in order to construct this alternative to meet this requirement.

The ET cap proposed under this alternative would meet the requirements of an engineered barrier for the ingestion and inhalation exposure routes under 35 IAC 742.1105. The completed ET cap would eliminate all other exposure routes to ecological receptors using the site as a food source. It is assumed that all location-specific ARARs (location near endangered species, wetlands, and secondary contact and indigenous aquatic life waters) would be waived since removal of waste materials is cost prohibitive. Action-specific ARARs for Illinois Pollution Control Board cover requirements may not be met by an ET cap during the selected vegetation's dormant season. The action-specific ARARs require that a barrier meeting a 1×10^{-7} cm/sec permeability be installed. It is uncertain as to whether an ET cap would meet these requirements during periods of active growth, and it is probable that during the winter months, the permeability requirements would not be met.

Under this alternative, IDOT material would not be extensively used. However, the soil would continue to be brought on to the LCC site and stockpiled. The soil needed to construct the ET layer would also have to be purchased and trucked to the site. Given the substantial increase associated with two separate and on-going shipments of materials coming to the site, this alternative has considerable adverse impacts in the short term. The amount of dust generation, noise, street cleaning, and material handling is effectively doubled because the IDOT material cannot be used.

Although this alternative does offer long-term permanence, it does require a high degree of maintenance. Maximizing plant uptake of water is key to the successful performance of this alternative. Ensuring plant health and survival would require constant monitoring and maintenance. Fertilization, pruning/mowing, harvesting, and replanting beyond the normal scope of O&M for a typical cap/cover system would have to be performed.

Under this alternative, there would not be a significant reduction of toxicity or volume. The ET cap would afford protection from direct contact exposure to waste and would decrease mobility of contaminants during periods when infiltration is controlled. The permeability of the cover would periodically allow infiltration of precipitation to continue the migration of contaminants from the site.

Technically, this alternative is implementable. From a construction standpoint, common construction equipment can be used, but the materials used in construction may require specialized blending to obtain the appropriate level of permeability and nutrients to sustain plant growth. Additionally, the engineering associated with plant selection will require individuals with specialized knowledge. It is uncertain as to whether this alternative can be implemented administratively. Since an ET cap will not meet the cover ARARs on a consistent basis, it is improbable that the appropriate permits could be obtained.

4.1.4 Alternative 4 - Capping of Existing Wastes with a Low-Permeability 35 IAC Part 724 Clay Cap

4.1.4.1 Description

Alternative 4 involves construction of a low-permeability clay cap meeting the requirements of Title 35 IAC Part 724 including gas collection and drainage layers, grading for stormwater containment and collection, construction of a stormwater retention pond with overflow to the Paxton I Landfill stormwater collection system, and vegetation of the entire site with native plants and prairie grasses. This alternative differs greatly from the previous alternatives in that a low-permeability cap would be installed; whereas under the previous alternatives surface water can readily migrate through the cover systems and come in contact with the waste material.

4.1.4.2 Evaluation

Alternative 4 provides protection of human health and the environment. It will prevent direct and indirect human exposure to the on-site contaminants. The low-permeability layer will significantly reduce the amount of surface water infiltration that would come into contact with the buried waste materials. Additionally, the drainage layer system, which has a cobble layer component, would effectively prevent burrowing animals from coming into contact with the subsurface contamination.

Because this alternative includes a low-permeability clay layer, it would meet all the ARARs, including the requirements for an engineered barrier for the ingestion and inhalation, as well as the soil component of groundwater ingestion, exposure routes under 35 IAC 742.1105. The completed 724 cap would eliminate all other exposure routes to ecological receptors using the site as a food source; however, the prairie grass vegetation and pond would create an "attractive nuisance" for birds, waterfowl, and small mammals. It is assumed that all location-specific ARARs (location near endangered species, wetlands, and secondary contact and indigenous aquatic life waters) would be waived since removal of waste materials is cost prohibitive. All action-specific ARARs for Illinois Pollution Control Board (35 IAC 724, 811, and 817) cover requirements would be met by a 724 cap.

During construction, short-term impacts from grading and material placement of the various cover layers would ensue; longer construction time is another short-term impact. These short-term impacts may include road closures/restrictions, street cleaning activities, and control of fugitive dust and debris. Long-term effectiveness and permanence are the highest under this alternative. This alternative also includes the installation of an LFG collection system, which also increases this alternative's short-term impacts.

Under this alternative, there would not be a significant reduction of toxicity or volume. The 35 IAC Part 724 cap would afford protection from direct contact exposure to wastes and would be effective at decreasing the mobility of subsurface contaminants. The low permeability of the cover would greatly reduce infiltration of precipitation, which would assist in reducing migration of contaminants from the site.

This alternative is readily implementable. It can be designed to meet the requirements of all the ARARs, and no special waivers from the State of Illinois would be required. Although a gas extraction system is proposed, an existing flare system with the capacity to treat the expected volume of collected gas is in place. By having a flare system in place, air permits would have to be modified, not obtained, reducing the amount of paper work and filings. The vegetative layer is standard for a cover system and would not require activities beyond what is normally expected. Since the flare is currently in operation, the addition of the new collection system should not prove to be problematic.

4.1.5 Alternative 5: Capping of Existing Wastes with a Low-Permeability 35 IAC Part 811 Clay Cap

4.1.5.1 Description

Alternative 5 involves construction of a low-permeability clay cap meeting the requirements of Title 35 IAC Part 811 including gas collection, grading for stormwater containment and collection, construction of a stormwater retention pond with overflow to the Paxton I Landfill stormwater collection system, and vegetation of the entire site with native plants and prairie grasses. This alternative differs from Alternative 4 in that a drainage layer would not be incorporated into the design, which would further reduce leachate generation and prevent burrowing animals from compromising the clay layer. While not specifically required under 35 IAC 811, a gas collection system was added to prevent gas generation from potentially damaging the low-permeability clay layer.

4.1.5.2 Evaluation

Alternative 5 provides protection of human health and the environment. The low-permeability clay layer provides protection of human health by preventing exposure to the waste material. Additionally, having a permeability of less than

1×10^{-7} cm/sec, the cap would provide a significant reduction of surface water infiltration into the waste material.

The 811 cap proposed under this alternative would meet all the requirements for an engineered cap under 742.1105. The completed 811 cap would eliminate all other exposure routes to ecological receptors using the site as a food source; however, the prairie grass vegetation and pond would create an “attractive nuisance” for birds, waterfowl, and small mammals. It is assumed that all location-specific ARARs (location near endangered species, wetlands, and secondary contact and indigenous aquatic life waters) would be waived since removal of waste materials is cost prohibitive. Not all of the action-specific ARARs of the Illinois Pollution Control Board’s cover requirements would be met by an 811 cap. Under 35 IAC 724, a drainage layer is required; therefore, this ARAR would not be met.

Short-term impacts associated with Alternative 5 include dust generation, construction noise, and an increase in local truck traffic. Control measures such as rerouting of traffic, and street cleaning may have to be implemented.

Under this alternative, there would not be a significant reduction of toxicity or volume. The 811 cap would afford protection from direct contact exposure to waste and would be effective at decreasing the mobility of contaminants. The low permeability of the cover would greatly reduce infiltration of precipitation, which would reduce the migration of contaminants from the site.

Technically, this alternative is implementable. The proposed cap does not require any specialized construction equipment or engineering design. While an LFG collection system has been incorporated into this alternative, these components are common systems to most landfill closure plans and should not prove to be problematic to implement. Administratively, re-permitting of the existing flare system would have to be implemented and a waiver for not meeting the requirements of 35 IAC 724 would have to be obtained. While the new flare permit is obtainable, it is uncertain as to whether a waiver for the cap can be obtained.

4.2 Comparative Analysis of Alternatives

In this subsection, the five interim remedial action alternatives are evaluated against one another using the seven EPA criteria described at the beginning of this Section 4.

4.2.1 Overall Protection of Human Health and the Environment

With the exception of Alternative 1, No Action, all of the interim remedial action alternatives provide some level of protection. Of the four remaining alternatives, Alternative 4 (724 Cap) provides the greatest level of protection of human health

and the environment. Alternative 4 provides the thickest low-permeability layer as well as a drainage layer, which would direct surface water that has infiltrated into the various layers of the cap away from the protective layer. The drainage layer system would also prevent burrowing animals from coming into contact with the waste. Additionally, LFG would be collected and routed to the flare system on Paxton I for thermal destruction. Alternative 5 (811 Cap) is similarly protective in that its low-permeability layer is the same thickness as Alternative 4 and also collects and provides for collection and destruction of LFG. However, there is no drainage layer associated with this alternative, so it is less protective of human health and the environment than Alternative 4.

Alternative 3 (ET Cap) is slightly more protective than Alternative 2 (Permeable Soil Cover) in that it is designed to limit the amount of surface water infiltration. However, during winter months when plant life is dormant, Alternative 3 would be expected to provide the same level of protection as Alternative 2.

4.2.2 Compliance with ARARs

With the exception of the No Action alternative, which does not meet any of the ARARs, the four remaining alternatives can be designed such that some, if not all, of the ARARs would be met. The main discriminator for this evaluation criterion is the type of cover system employed by the various alternatives. Therefore, this section will focus on how the action alternatives meet the ARARs associated with the covers.

Of the four interim remedial action alternatives, Alternative 4 (724 Cap) meets all the requirements presented for covers (i.e., 35 IAC 724, 742, 811, and 817). Alternative 5 (811 Cap) meets the requirements of 35 IAC 817, but not IAC 724. Alternatives 2 (Permeable Soil) and 3 (ET Cap) do not meet the requirements for a cover system since a protective barrier meeting the 1×10^{-7} cm/sec permeability standard is not provided.

4.2.3 Short-Term Impacts and Effectiveness

The No Action alternative would have the least short-term impact in that nothing would be implemented or constructed. The short-term impacts posed by Alternative 2 (Permeable Soils Cover) would be less significant than the other alternatives because this alternative involves the least amount of earthwork.

Given the extensive material handling associated with the cover systems and surface water drainage, Alternatives 4 (724 Cap) and 5 (811 Cap) would have more short-term effects than Alternative 2, with Alternative 4 posing slightly greater impacts than Alternative 5 in that a drainage layer would be installed as part of its construction.

Alternative 3 (ET Cap) has greatest short-term impacts. While the other alternatives use IDOT material, Alternative 2 requires a significant amount of soil to be imported to the site. Assuming that the IDOT material will continue to be brought on site, the additional shipments associated with bringing the ET cap material on site will greatly increase traffic. This causes Alternative 3 to have the most adverse effects in the short term.

4.2.4 Long-Term Effectiveness and Permanence

While Alternative 1 (No Action) provides no long-term effectiveness or permanence, all of the remaining alternatives would provide some level of long-term effectiveness, assuming proper O&M of the covers and ancillary systems.

All the interim remedial action alternatives can be readily maintained to consistently meet their design objectives. While Alternative 2 (Permeable Soil Cover) will be the easiest to maintain in that the vegetative cover requires standard care, surface water infiltration into the waste material will continue unabated. Therefore, Alternative 2 offers only slightly more permanence than Alternative 1.

The vegetative cover associated with Alternative 3 (ET Cap) will require significantly more care than Alternative 2. However, on yearly basis, there will be less surface water infiltration into the waste than under Alternative 2. Therefore, Alternative 3 offers more long-term permanence than Alternative 2.

Long-term effectiveness under Alternatives 4 and 5 would be approximately the same. While both alternatives require cover maintenance, they also require the operation of a gas collection system. The gas collection system should not prove to be problematic given the flare is in operation and utilizes experienced technicians. With the drainage system providing an additional reduction in surface water infiltration and preventing burrowing animals from entering the waste, Alternative 5 offers the most long-term permanence and effectiveness.

4.2.5 Reduction of Toxicity, Mobility, and Volume

None of the alternatives presented will reduce the volume or toxicity of the waste present on site. However, the mobility or ability to leach contamination into the groundwater or nearby surface waters would be different for several of the alternatives.

Alternative 1 (No Action) does not provide for any reduction in the mobility of contaminants. Of the four interim remedial action options, Alternative 2 (Permeable Soil Cover) would provide the least reduction in contaminant mobility because precipitation would readily infiltrate to the subsurface. Alternative 3 provides a slightly greater degree of reduction of contaminant mobility than Alternative 2. However, during periods of dormant plant activity, surface water

would readily infiltrate through the cap providing approximately the same level of reduction in mobility as Alternative 2.

While Alternatives 4 and 5 are similar, Alternative 5 (724 Cap) provides a greater reduction of contaminant mobility in that a drainage layer is incorporated into its design. The drainage layer would further reduce the potential for surface water to infiltrate into the waste.

Implementability

Of the five alternatives, Alternative 1 (No Action) is the most implementable. Alternative 2 (Permeable Soil Cover) is the next most readily implementable alternative since it involves the least amount of soil grading and placement. Administratively, however, this alternative could be the most difficult since it does not meet the ARARs associated with a cover design.

Alternative 4 (724 Cap) is the most difficult alternative to construct. As stated previously, this alternative includes the installation of a gas collection system and a drainage layer, which each require additional construction effort and expertise. Alternative 5 (811 Cap) is only slightly more implementable than Alternative 4 in that the drainage layer would not be constructed, and a waiver for not meeting the requirements of 35 IAC 724 would be required.

Implementing Alternative 3 (ET Cap) would involve a similar level of construction and expertise as that posed by Alternative 5. While the cap is less complex than Alternative 5, special soils would have to be imported and additional O&M would be needed to ensure that plant life is maintained. Additionally, data gathering needs would be greater since water balance calculations would have to be performed to ensure that the cover system is functioning properly. As with Alternative 2, it is uncertain as to whether a waiver could be obtained for its cover.

Cost

Under this section, the costs associated with implementing the alternatives are compared against each other. Using the present worth value for each alternative, Alternative 3 (ET Cap) is the most expensive (\$19,730,000) with the main cost driver being that the soils used to construct the ET layer will have to be purchased and imported. Alternative 4 (724 Cap) is the next most expensive alternative, having a present worth cost of \$18,970,000, which is slightly more than the cost associated with Alternative 5 (811 Cap) of \$17,160,000. The discriminating factor between these two alternatives is the installation of the drainage layer.

With no specialized layers or LFG collection system being implemented, Alternative 2 (Permeable Soil Cover) has a present worth cost of \$11,900,000, which makes it the least expensive of the interim remedial action alternatives. For



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Alternative 1 (No Action), there are no costs. Table 4-3 provides a summary of costs for each alternative.

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**Table 4-1 Individual Analysis of Alternatives
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois**

Remedial Alternative	Evaluation Criteria					Cost* Construc- tion, 30-Year O&M, Total
	Protection of Human Health and the Environment	Compliance with ARARs	Short-Term Impacts and Effectiveness	Long-Term Effectiveness and Perma- nence	Reduction in Toxicity, Mobility, and Volume	Implementability
Alternative 1: No Action	No additional protection provided.	Does not comply.	No short-term impacts.	Does not provide any effectiveness or permanence.	No reduction achieved.	Readily implement- able. \$0 \$0 \$0
Alternative 2: Permeable Soil Cover	Provides protection of human health and limited environ- mental protection.	Can be designed to meet most ARARs. Does not comply with 35 IAC 724.1105, 724, 811, or 817.	Short-term impacts include increased truck traffic, noise, and dust generation.	Provides limited effectiveness and permanence.	No reduction in toxicity or volume, limited reduction in mobility.	Readily implement- able. IDOT soils can be used for majority of cover. Waiver for cover must be obtained. \$10,900,000 \$ 1,000,000 \$11,900,000
Alternative 3: Evapotranspiration Cap	Provides protection of human health and limited environ- mental protection.	Can be designed to meet most ARARs. Does not comply with 35 IAC 724.1005, 724, 811, and 817.	Short-term impacts include increased truck traffic, noise, and dust generation.	Provides limited effectiveness and permanence. Vegetation requires extensive care.	No reduction in toxicity and volume, slight reduction in mobility.	Readily implement- able. However, IDOT soils cannot be used. Waiver for cap must be obtained. \$18,730,000 \$ 1,000,000 \$19,730,000
Alternative 4: 35 IAC 724 Cap	Provides protection for human health and the environment.	Can be designed to meet all ARARs.	Short-term impacts include increased truck traffic, noise, and dust generation.	Provides long-term effectiveness; however, flare system must be operated and maintained to protect cap.	No reduction in toxicity and volume, but does reduce contaminant mobility.	Readily implement- able. IDOT soils can be used for majority of work. \$17,700,000 \$ 1,280,000 \$18,980,000

4. Detailed Analysis of Alternatives

Focused Feasibility Study Section No.: 4

Revision No.: 1

Date: June 2006

Table 4-1 Individual Analysis of Alternatives
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois

Remedial Alternative	Evaluation Criteria					Cost* Construc- tion, 30-Year O&M, Total
	Protection of Human Health and the Environment	Compliance with ARARs	Short-Term Impacts and Effectiveness	Long-Term Effectiveness and Perma- nence	Reduction in Toxicity, Mobility, and Volume	Implementability
Alternative 5: 35 IAC 811 Cap	Provides protection for human health and the environment.	Can be designed to meet most ARARs. Does not comply with 35 IAC 724.	Short-term impacts include increased truck traffic, noise, and dust generation.	Provides long-term effectiveness; however, flare system must be operated and maintained to protect cap.	No reduction in toxicity and volume, but does reduce contaminant mobility.	Readily implement- able. IDOT soils can be used for majority of work. Waiver from 35 IAC 724 ARAR must be obtained.
						\$15,900,000 \$ 1,280,000 \$17,180,000

* Costs rounded to nearest \$10,000.

4. Detailed Analysis of Alternatives

Focused Feasibility Study Section No.: 4

Revision No.: 1

Date: June 2006

Table 4-2 Comparative Analysis of Alternatives
Focused Feasibility Study, Lake Calumet Cluster Site, Chicago, Cook County, Illinois

Remedial Alternative	Evaluation Criteria					Implementability	Cost
	Protection of Human Health and the Environment	Compliance with ARARs	Short-Term Impacts and Effectiveness	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, and Volume		
Alternative 1: No Action	Provides no increased protection and is least protective overall.	Provides no compliance.	Provides no short-term impacts.	Provides no long-term effectiveness.	No reduction is achieved.	The site remains the same; therefore, most implementable.	No cost associated with this alternative.
Alternative 2: Permeable Soil Cover	More protective than Alt. 1; provides limited protection to the environment since surface water migration through the waste will continue.	More compliant with ARARs than Alt. 1. Does not meet the ARARs associated with cover systems.	Least complex cover system and has the least adverse impacts in the short-term.	Limited effectiveness in the long-term, and does not offer permanence.	Regrading will allow for a limited reduction in mobility.	The cover system is the least complex; therefore it is more implementable than other alternatives.	Least expensive of all action alternatives.
Alternative 3: Evapotranspiration Cap	Provides human health protection and is more protective of the environment than Alt. 2. However, during dormant periods of plant growth, surface water will migrate through the cover.	More compliant with ARARs than Alt. 1. Does not meet the ARARs associated with cover systems.	More complex than Alt. 2, but less complex than Alt. 4 and 5. However, most material will have to be imported, greatly increasing truck traffic.	Vegetative cover will require extensive O&M. While more effective than Alt. 2, it is less effective than Alt. 4 and 5.	Reduces infiltration and mobility during the growing season; however during dormant growing periods, mobility will be the same as Alt. 2.	Based on cover construction requirements, more implementable than Alts. 4 and 5, but majority of soils must be imported, and a waiver for construction must be obtained.	Given that IDOT soils cannot be readily used, this alternative is the most expensive.

Table 4-2 Comparative Analysis of Alternatives

Evaluation Criteria							
Remedial Alternative	Protection of Human Health and the Environment	Compliance with ARARs	Short-Term Impacts and Effectiveness	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, and Volume	Cost	
						Implementability	Cost
Alternative 4: 35 IAC 724 Cap	Provides the greatest level of protection of alternatives analyzed.	Only Alternative that can meet all the ARARs.	Most complex cover system. However, IDOT soils can be used, so less traffic and fewer impacts than Alt. 3.	Effective in the long-term; however, O&M of flare system is required.	Has the greatest reduction in mobility of all alternatives.	Most complex cover system to build; however, Alt 4 is still readily implementable.	Cost is 10% greater than Alt. 5.
Alternative 5: 35 IAC 811 Cap	Slightly less protective than Alt. 4 in that it does not have a drainage layer. Significantly more compliant than Alts. 1, 2, and 3.	More compliant than Alts. 1 and 2, and meets all ARARs with the exception of 35 IAC 724.	Has no drainage layer, therefore, short-term impacts are less than Alt 4.	Effective in the long term; however, O&M of flare system is required. This alternative is slightly less effective than Alt. 4 because it lacks a drainage layer.	Does not have a drainage layer; therefore, does not reduce mobility as well as Alt. 4.	Not having a drainage layer, is slight more implementable than Alt 5.	Second most expensive alternative. No drainage layer system. Main difference between this alternative and Alt 4

**Table 4-3 Comparative Summary of Alternative Costs
Lake Calumet Cluster Site, Chicago, Cook County, Illinois**

Alt.	Description	Capital Cost	O&M Cost	Alternative Cost
1	No Action	\$0	\$0	\$0
2	Capping of existing wastes with a permeable soil cover	\$ 10,899,000	\$ 1,000,000	\$ 11,900,000
3	Capping of existing wastes with an evapotranspiration (ET) cap	\$ 18,730,000	\$ 1,000,000	\$ 19,730,000
4	Capping of existing wastes with a Low-Permeability 35 IAC Part 724 clay cap	\$ 17,700,000	\$ 1,280,000	\$ 18,980,000
5	Capping of existing wastes with a Low-Permeability 35 IAC Part 811 clay cap	\$ 15,900,000	\$ 1,280,000	\$ 17,180,000

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Conclusions

EEEI was tasked by the Illinois EPA to prepare this Focused Feasibility Study for the Lake Calumet Cluster Site. The results from the human health risk assessment and ecological risk assessment indicate that there is an unacceptable level of risk associated with the buried wastes at the site. Therefore, the objective of the FFS was to develop and evaluate potential interim remedial action alternatives for the site. Since the buried waste is present at various locations throughout the 90-acre site, capping was considered the most viable approach to address the contamination. This is consistent with EPA's presumptive remedy guidance for municipal landfill sites.

Using EPA's guidance document, *Presumptive Remedy for CERCLA Municipal Landfill Sites*, the following Remedial Action Objectives were established for the site:

- Prevent direct and dermal contact with, and ingestion of, contaminated soil/waste contents;
- Prevent inhalation of dust;
- Minimize or eliminate contaminant leaching to groundwater;
- Prevent ingestion, adsorption, and bioconcentration of on-site surface water and sediment;
- Prevent explosion or fire from accumulations of LFG; and
- Prevent inhalation of COPCs in the LFG in excess of benchmark concentrations.

Using the presumptive remedy of capping, the following alternatives were developed for the LCC site:

- **Alternative 1 – No Action:** The LCC site would remain unchanged. No cover system would be implemented. As required by the NCP, this alternative is included to provide a basis for comparison with the remaining remedial action objectives.



- **Alternative 2 – Capping of Existing Wastes with a Permeable Soil Cover:** For this alternative, the entire site would have a permeable soil cover placed over it, while creating an appropriate grade for stormwater retention. Activities included under this alternative include site preparation/grading, placement of the cover material and planting of a vegetative cover, which consists of native plants and prairie grasses. This alternative would also utilize the imported IDOT fill material.
- **Alternative 3 – Capping of Existing Wastes with an Evapotranspiration (ET) Cap:** Under this alternative an ET cap would be placed over the majority of the site. The ET cap would utilize evaporation as well as vegetative uptake of surface water to prevent infiltration of surface water into the waste causing contaminants to leach into the groundwater. Potential vegetation to be used for this alternative includes a mixture of warm- and cool-season native grasses, shrubs, and trees. Given the necessary soil properties associated with an ET cover, the imported IDOT material would likely not be suitable for use with this alternative.
- **Alternative 4 – Capping of Existing Wastes with a Low-Permeability 35 IAC 724 Clay Cap:** This alternative involves construction of a low-permeability clay cap over the existing wastes while creating an appropriate grade for stormwater runoff. This alternative involves construction of a low-permeability clay cap meeting the requirements of IAC Title 35 Part 724, grading for stormwater containment and collection over the entire site, construction of a stormwater retention pond with overflow to the Paxton I Landfill stormwater collection system, installation of a gas collection system, and vegetation of the entire site with native plants and prairie grasses.
- **Alternative 5 – Capping Existing Wastes with a Low-Permeability 35 IAC 811 Clay Cap:** Alternative 5 involves construction of a cover system which consists of a low-permeability clay layer overlain by a protective layer, which would protect it from freezing. Both the low-permeability layer and protective layer will be constructed using IDOT material. While not a requirement of 35 IAC 811, this alternative includes a gas collection system to protect the integrity of the clay layer. Additionally, grading for stormwater containment and collection over the entire site, construction of a stormwater retention pond with overflow to the Paxton I Landfill stormwater collection system, and vegetation of the entire site with native plants and prairie grasses would be performed.

Sections 3 and 4 of this FFS provided an evaluation of each of the alternatives, and a comparative analysis of the alternatives. The No Action alternative would leave the site in its present condition, and would provide no protection to human health and the environment. Alternatives 2 and 3 would be somewhat protective

in that the waste materials would be covered, but infiltration would not minimize or prevent continued migration of contaminants from the site. Alternatives 4 and 5 are the most protective, covering the site with a low-permeability cap and reducing the potential for continued migration of contaminants.

In regard to the ARARs, only Alternative 4 could be implemented to meet all of the ARARs. Alternative 5 could meet the majority of ARARs; however, the requirements of 35 IAC 724 would not be met. Alternatives 2 and 3 do not meet the majority of the ARARs associated with capping/cover, and the No Action Alternative does not meet any of them.

Alternative 3 has the most adverse short-term impacts because the imported IDOT soil cannot be used for the majority of its cover installation, and the required additional soil material would have to be trucked to the site. Given that there is approximately the same amount of earthwork involved, Alternatives 4 and 5 have similar degrees of short-term effectiveness. Alternative 2 requires less earthwork, so it has less of an adverse effect in the short term than Alternatives 4 and 5. The No Action alternative has the least amount of adverse effects in the short-term since no remedial action is performed.

Alternative 1 provides no long-term permanence. Given that surface water will continue to migrate through the cap, leaching contaminants into the groundwater, Alternative 2 does not offer long-term permanence. During seasonal plant growth periods, Alternative 3 would reduce the amount of surface water infiltration. However, during periods of dormant vegetative activities, surface water infiltration into the waste material will occur. While more effective than Alternative 2, Alternative 3 does not provide long-term permanence. Both Alternatives 4 and 5 provide for long-term permanence. However, both alternatives require a flare system to be operated to address the collected LFG.

Using the presumptive remedy of capping, there will not be a reduction in toxicity or volume of contamination. However, there can be a reduction in mobility using this presumptive remedy. Alternative 5, which utilizes a clay cap and a drainage layer to prevent surface water from infiltrating into the waste, provides the greatest reduction in contaminant mobility. Alternative 5, which is similar to Alternative 4 but does not have a drainage layer, does not provide as much of a reduction in mobility as Alternative 4. Alternatives 2 and 3 are both constructed of permeable materials, and surface water will infiltrate into the waste, leaching contaminants into the groundwater. Given that Alternative 3 provides for evapotranspiration to occur, it does provide more of a reduction in mobility than Alternative 3. The No Action alternative provides for no reduction in mobility.

The most implementable alternative is Alternative 1, No Action. Given the amount of IDOT material that is presently or will be on the site, Alternatives 2, 4,

and 5 are more implementable than Alternative 3, which will require the importation of the majority of soil for its cover system. Of the three alternatives using IDOT soils, Alternative 2 is the most implementable since its cover is relatively simple. However, it is doubtful that a waiver for the ARARs associated with capping could be obtained for this alternative. Given that it has more specific layers associated with its construction, Alternative 4 will be slightly more difficult to implement than Alternative 5.

Since the majority of its material will have to be purchased and transported to the site, Alternative 3 is the most expensive alternative to implement. With its multiple layers and LFG collection system, Alternative 4 is the next most expensive alternative, with Alternative 5 being slightly less. Alternative 2 is the least expensive of the interim remedial action alternatives because of its relatively simple design. Finally, there is no cost associated with the No Action alternative.

Under an agreement with the Illinois EPA, IDOT has been and continues to bring excess soil from its Dan Ryan expansion project to the LCC site. Wherever possible, the alternatives developed for this FFS have used the IDOT material as part of the soils needed for the construction of the various layers associated with its cover system.

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Human Health Risk Assessment (HHRA) Report for the LCC Site: Alburn, U.S. Drum II, and Unnamed Parcel Areas - Final Report, February 2002

HUMAN HEALTH RISK ASSESSMENT REPORT

LAKE CALUMET CLUSTER SITE:
ALBURN, U.S. DRUM, AND UNNAMED PARCEL AREAS

FINAL REPORT

Prepared for

City of Chicago Department of Environment
Chicago, Illinois

By



MWH

MONTGOMERY WATSON HARZA

February 2002

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LIST OF ACRONYMS

ADD	Average Daily Dose
bgs	Below Ground Surface
COPCs	Chemicals of Potential Concern
CSM	Site Conceptual Model
DOE	City of Chicago Department of Environment
E & E	Ecology & Environment, Inc
EDQL	Ecological Data Quality Levels
ELCR	Excess Lifetime Cancer Risks
EPC	Exposure Point Concentration
GPS	Global Positioning System
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IAC	Illinois Administrative Code
IEPA	Illinois Environmental Protection Agency
ISWS	Illinois State Water Survey
LADD	Life Average Daily Dose
LOAEL	Lowest Observed Adverse Effect Level
MF	Modifying Factor
NOAEL	No Observed Adverse Effect Level
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
RAGS	Risk Assessment Guidance for Superfund
RfDs	Reference Doses
RO	Remediation Objectives
SF	Slope Factor
SI	Site Investigation
SVOC	Semivolatile Organic Compound
TACO	Tiered Approach to Corrective Action
TCLP	Toxic Characteristic Leaching Procedure
UCL	Upper-bound Confidence Limit
UF	Uncertainty Factor
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
XRF	X-Ray Fluorescence

EXECUTIVE SUMMARY

This report describes and summarizes a human health risk assessment (HHRA) conducted at Alburn Incinerator (Alburn), U.S. Drum II (U.S. Drum), and Unnamed Parcel areas, referred as the Lake Calumet Cluster Site (Cluster Site), in Chicago, Cook County, Illinois. Soil, sediment, surface water and groundwater data collected and analyzed during several investigations at the Cluster Site were used in the HHRA. These site investigations include Phase I, Phase II and Phase III samplings conducted by Ecology & Environment, Inc. (E & E) and Illinois Environmental Protection Agency (IEPA) in 1998 and 1999; and a comprehensive site investigation (SI) conducted by IEPA in 2000. All laboratory-generated data were compiled and used in this risk assessment. The selection of Chemicals of Potential Concerns (COPCs) is based on different screening criteria in each media. For soil contaminants, the Tier I Soil Remediation Objectives (ROs) for residential scenario from IEPA's Tiered Approach to Corrective Action (TACO) were used as the screening criteria. Groundwater contaminants were screened against Class I groundwater ROs from TACO. The selection of COPCs in sediment and surface water were based on the evaluation conducted by E & E. The potential receptors for the Cluster Site include on-site workers, mowers, construction workers, industrial/commercial workers and landscape workers. Completed pathways for each potential receptor exposed to COPCs were identified. Carcinogenic risk and noncarcinogenic hazard for each potential receptor were quantitatively estimated. An excess lifetime cancer risk (ELCR) value and a hazard index (HI) value were estimated to evaluate the carcinogenic risks and noncarcinogenic hazards, respectively.

The risk characterization indicates that in Alburn, U.S. Drum and Unnamed Parcel, risks are primarily due to exposure to soil. Risks due to exposure to sediment, surface water and groundwater are insignificant. In Alburn, risks due to exposure to soil exceeds ELCR of $1E-06$ for all receptors and the primary COPCs are arsenic, benzo(a)pyrene, total PCBs and vinyl chloride. For noncarcinogenic hazard, exposure to soil for construction workers exceed HI of 1 and the primary COPC is toluene. In U. S. Drum, the carcinogenic risk exceeds $1E-06$ in soil for all receptors and the primary COPCs are arsenic, benzo(a)pyrene, dibenz(a,h)anthracene and total PCBs. In Unnamed Parcel, the carcinogenic risk due to exposure to contaminants in soil exceeds $1E-06$ for on-site workers, industrial/commercial workers and mowers and the primary COPCs in soil for carcinogenic risk are arsenic and benzo(a)pyrene. No noncarcinogenic hazard exceeds 1 for all receptors due to exposure to contaminants in U. S. Drum and Unnamed Parcel.

1.0 INTRODUCTION

The City of Chicago Department of Environment (DOE) is currently investigating the Lake Calumet Cluster Site (Cluster Site), located in Chicago, Cook County, Illinois. The City has plans for developing this site. Future potential use of the Cluster Site includes use as a solar power generating station. Risk assessments are used to determine the need for remediation and to establish protective clean-up goals in the context of the desired end use for contaminated sites. This human health risk assessment (HHRA) addresses the potential risks associated with the Cluster site that could occur due to exposure to contaminants in the absence of remedial measures.

The HHRA was prepared in accordance with USEPA's "Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, Part A" (USEPA, 1989), and other supplementary USEPA guidance documents, as listed below:

- Guidance for Data Usability in Risk Assessment, 1992a.
- Exposure Factors Handbook, 1997.
- Supplemental Guidance to RAGS: Calculating the Concentration Term, 1992b.

This HHRA report describes the methodology and assessment of human health risk. The report is organized as follows:

1.0 *Introduction*: Purpose and objectives of the HHRA

2.0 *Background*: Site characterization, description and history, site investigation

3.0 *Data Evaluation and Selection of Contaminants of Potential Concern*

4.0 *Exposure Assessment*: Identification of human receptors; description of the exposure pathways and quantification of exposure from each exposure pathway

5.0 *Toxicity assessment*: Identification of carcinogenic and noncarcinogenic health effects criteria and assessment

6.0 *Risk characterization*: Calculation of carcinogenic risks and noncarcinogenic hazards

7.0 *Uncertainties*: Discussion of uncertainties associated with the HHRA

8.0 *Conclusions*: Summary of the human health risk assessment

9.0 *References*

2.0 BACKGROUND

2.1 Site Location

The Cluster Site is located in the southeastern edge of Chicago, Illinois (Township 37 North Range 14 East, Section 24). The property is in the Lake Calumet region, a heavily industrialized area of southeast Chicago. Land and Lakes Landfill are located to the west of the property. Paxton I Landfill is to the north of the property. The Norfolk and Western Railroad right-of-way forms the eastern boundary, and 122nd Street forms the southern boundary of the site. A site location map is presented as Figure 1.

2.2 Site Description

The Cluster Site is approximately 87 acres and consists of unimproved upland with several depressional areas that are seasonally flooded. The National Wetland Inventory Map has identified approximately two acres within the lower depressional areas on site as permanently flooded open water wetlands. The relatively flat dry upland dips gently from west to east and is made up of grasses, weeds, bushes, trees, and paved roadways and yard areas.

2.3 Site History

The Lake Calumet region, prior to development in the late 1800s, was composed of wetlands, marshes, bogs, and shallow lakes. To make this region suitable for development, large areas of wetlands were filled in with slag wastes from steel production, dredgings from the Calumet River, fly ash, solid industrial wastes, demolition debris, and household trash (Roadcap and Kelly 1994).

2.4 Geology/Hydrogeology

This section describes the regional and site-specific geology and hydrogeology at the Cluster Site. The regional information is derived from geologic literature and available water well drilling logs obtained from the Illinois State Water Survey (ISWS). The site-specific geology and hydrogeology is based on test pits conducted during this site investigation and information obtained from previous site activities, including boring logs and monitoring well data.

2.4.1 Regional Geology

The Cluster Site is located within the Chicago/Calumet Lacustrine Plain, which is a glacially formed, low, crescent-shaped flat surface that slopes gently to Lake Michigan. The Plain extends from the Wilmette, Illinois area to the Indiana-Michigan border and continues northward in a narrow band along the Michigan shore (Chrzastowski and Thompson, 1993). The Chicago/Calumet Lacustrine Plain surface is primarily a wave-scoured ground moraine with fine lake silts and clays covering the surface in former back-barrier settings. The prominent depositional features on the plain are sand and gravelly sand spits, mainland beaches, and beach-ridge/dune complexes. This lowland region drains into Lake Michigan. The bedrock geology of the region consists of Precambrian-age crystalline rock overlain by gently dipping Paleozoic sedimentary bedrock units. The uppermost bedrock unit consists of eastward gently dipping Silurian dolomite. The Racine formation, the youngest formation of the Silurian period,

underlies the area due to the eastward dip of the rock strata. The Racine formation includes a number of organic reefs, which consist of a core of massive, high-purity dolomite flanked by dipping dolomite beds. The bedrock surface topography is an undulating plain as a result of glacial and some lake erosion, in which scattered steep valleys and low bedrock hills occur. Mapping by Piskin and Bergstrom (1975) indicates that the bedrock is overlain by approximately 50 to 100 feet of unconsolidated Quaternary age deposits. According to Chrzastowski and Thompson (1993), the site is filled with a dark gray, silty clay till that is correlative to the Wadsworth Formation. This till unit intertongues with bedded sands and silt, which are assigned to the Henry and Equality Formation.

2.4.2 Regional Hydrogeology

According to Suter et al. (1959), the four primary aquifers recognized in the Chicago area are the Sand and Gravel Aquifers within the glacial drift, the Shallow Bedrock Aquifers mainly Silurian in age, the Cambrian-Ordovician Aquifer, and the Mt. Simon Aquifer.

The uppermost bedrock aquifer underlying the Lake Calumet region is composed of Silurian dolomites. Suter et al. (1959) have indicated that groundwater in the shallow dolomite occurs in joints, fissures, and solution cavities. Therefore, yields at any given location are unpredictable. The openings in the dolomite mainly occur in the upper part of the rock. Therefore, it is likely there is good connection between the shallow bedrock aquifers and the overlying glacial drift. It follows that where fractured dolomite is overlain by sand and gravel deposits there will be more immediate recharge of the shallow dolomite aquifer than in areas where glacial till rests on the bedrock.

The uppermost aquifer system identified in the vicinity of the Cluster Site is the glacial drift aquifer, composed of unconsolidated Quaternary deposits. In the vicinity of the site, the glacial drift aquifer consists of sands overlying and interbedded with glacial till.

2.4.3 Site Geology

Based on site investigations, the near surface geology consists of unconsolidated glacial deposits overlain by various fill materials over most of the site. From bottom to top, the following geologic materials, were encountered: Gray/Brown silty clay; Gray silty sand and Fill.

The gray/brown silty clay unit is the lowermost unit encountered at the site and is composed of silty clay with a trace of fine sand and gravel. The silty clay was encountered only in wells at depths ranging from 14.5 to 24 feet. The sand unit is composed of varying percentages of medium to fine grained sand with silt, and exhibits brown to gray color variations. The fill material is composed of various household wastes.

2.4.4 Site Hydrogeology

The hydrogeology of the site was described using data collected during monitoring well installation performed by Ecology and Environment Inc. (E &E) in 1999 (E & E, 1999a). Groundwater was encountered in all twelve wells at different elevations.

Data collected during monitoring well installation suggest that the aquifer is semi-confined with a head between 1 to 4 feet. Slightly confined conditions may be the result of clay layers within the fill material.

Groundwater in monitoring wells installed by E & E and in test pits performed during a site investigation conducted by IEPA in 2000 stabilized between ground surface and 10 feet below ground surface. In some low areas, the water table in the pits was encountered about 2 feet above ground surface.

Generalized potentiometric contours for fill and sand were developed using data collected during monitoring well installation (MWH, 2001). The contours demonstrate that flow onto the site is from the west and flow within the site is northeast, east, and southeast. Groundwater probably discharges to Indian Ridge Marsh to the east and Big Marsh to the north. Two landfills located northwest and southwest of the site may influence groundwater flow direction. The interaction between groundwater and surface water on the site is very complicated due to the extreme heterogeneity of the fill material and local flow direction may differ from general flow direction on the site.

No hydraulic conductivity tests were performed on site. The value of hydraulic conductivity cited in the literature for fine and medium sand is between 1×10^{-3} cm/s and 1×10^{-2} cm.

2.5 Site Investigation

Samples from the Cluster Site were collected and analyzed during several site investigations. These investigations include Phase I, Phase II, and Phase III samplings conducted by EPA's contractor E & E, EPA and IEPA in 1998 and 1999; and a site investigation conducted by IEPA in 2000. Samplings were conducted at three areas at the Cluster Site: Auburn, U.S. Drum and Unnamed Parcel. The media sampled include soil, sediment, surface water and groundwater. Figure 2 shows the sample locations at the Cluster Site.

2.5.1 Phase I

Phase I sampling activities were conducted from August 24, 1998 to September 3, 1998 by E & E, USEPA, and IEPA. Sampling included determining the location of site features and potential sample locations using global positioning systems (GPS), screening metal concentrations in surface soils using X-ray fluorescence (XRF), and collecting samples of surface soils, subsurface soils, sediments, surface water, groundwater, and macroinvertebrates. Access to the Auburn area was not available to E & E, USEPA, and IEPA. Therefore, no samplings were conducted at Auburn at this time.

The geographic locations of site features, including parking lots, roads and fence lines, and potential sample locations were demarcated using GPS and screened using XRF. Screening was conducted for molybdenum, strontium, rubidium, lead, arsenic, mercury, zinc, copper, nickel, cobalt, manganese, and chromium.

Sampling included:

- Eighty four surface soil samples and four duplicate samples;
- Five subsurface soil samples and one duplicate;
- Three groundwater samples; and
- Eight surface water, sediment, and macroinvertebrate samples.

Samples were analyzed for total metals, toxicity characteristic leaching procedure (TCLP) metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), pH, and percent moisture. Sample results indicated several discrete areas with contaminant concentrations exceeding human health standards and the ecological threshold.

2.5.2 Phase II

Twelve monitoring wells (LC01 to LC07 and LC09 to LC13) were installed in April 1999. Five wells were installed in October 1990 (P01 to P05). Wells were completed to depths of 14 to 16 feet below ground surface (bgs) except LC09 and LC11, which were completed to 20 feet bgs. Pairs of wells were constructed within five feet of each other creating nested well clusters at the following locations: LC09/LC10, and LC11/LC12. E & E (1999b) listed P05/LC07 as a well pair. No construction details are available in the report for P05; however, the other four wells constructed at the same time were placed 10 ft bgs or deeper. The nested wells allow groundwater to be collected from different depths in the same area.

The 12 new wells and 6 existing wells were sampled in May 1999 for total metals, VOCs, SVOCs, pesticides, PCBs, nitrogen, and pH. Field parameters were also collected including temperature, dissolved oxygen, specific conductivity, oxidation/reduction potential, and pH.

2.5.3 Phase III

Phase III sampling was performed in May-June 1999 and included: sampling at Auburn to address data gaps from Phase I; obtaining additional surface and subsurface soil data near areas of elevated concentrations identified in Phase I; collecting additional surface water and sediment samples at or near Auburn; and collecting nitrogen data from previous surface water locations. Soil samples included 39 surface samples, 15 subsurface samples between 2 and 3 ft bgs, and 15 subsurface samples between 4 and 6 ft bgs. Samples were analyzed for total metals, VOCs, SVOCs, pesticides, PCBs, pH, and percent moisture. Four surface water samples collected from ponded water in and near Auburn were analyzed for total metals, VOCs, SVOCs, pesticides, PCBs, and pH. Sixteen surface water samples were collected for nitrogen analysis (four in Auburn, eight in Indian Ridge Marsh, and four from large ponds). Seven sediment samples in and near Auburn were analyzed for total metals, VOCs, SVOCs, pesticides, PCBs, and percent moisture/percent solids.

2.5.4 IEPA Site Investigation (SI)

IEPA conducted site investigation activities at Auburn from June 19 through 22, 2000; Unnamed Parcel from July 17 through 20, 2000; and U.S. Drum from August 21 through 25, 2000. The investigative activities consisted of using a backhoe to sample a total of 134 test pits, including 44 test pits in Auburn, 39 test pits in Unnamed Parcel, and 51 test pits in U.S. Drum. The SI comprised sampling of soils from test pits. Two or more samples were collected from each of

134 test pit locations in the three areas. Samples were analyzed for inorganics, VOCs, SVOCs, pesticides/herbicides and PCBs. Dioxins were also analyzed in some locations.

3.0 SELECTION OF CONTAMINANTS OF POTENTIAL CONCERNS

The laboratory analytical data for samples collected during IEPA SI were generated following analytical procedures detailed in the United States Environmental Protection Agency (USEPA) and Illinois Environmental Protection Agency (IEPA) approved Quality Assurance Project Plans. Available analytical data from the SI were evaluated to determine usability in the risk assessment (EPA, 1992a). All laboratory generated analytical data were compiled and used in this risk assessment except for the screening level data generated during field investigations, which include metal data generated using XRF and groundwater samples collected using a geoprobe during Phase I. Data collected during Phase I, II and III were evaluated by E & E (1999b) and summarized in this section. The selection of contaminants of potential concern (COPCs), carcinogenic risk and noncarcinogenic hazard characterizations are discussed separately on Auburn, U.S. Drum and Unnamed Parcel areas in the Cluster Site.

3.1 Soil

Soil samples collected and analyzed during the comprehensive SI conducted by IEPA during 2000 are used in this HHRA. Metals are naturally occurring in soil. Metal concentrations that do not exceed background levels are not considered in estimating carcinogenic risks and noncarcinogenic hazards. Contaminant concentrations in soil were compared against soil background values. The soil background values were obtained from title 35 of the Illinois Administration Code (IAC) Part 742, *Tiered Approach to Corrective Action Objectives* (TACO)(IEPA 2001). Background concentrations specific for counties within Metropolitan Areas were used in this evaluation. Analytes that were found to be present at concentrations exceeding background concentrations were retained for further evaluation. Chemical concentrations in soils were then screened against the Tier I Soil Remediation Objectives (ROs) from IEPA (2001). The analytical results were compared to ROs for residential scenario. Chemicals detected in soil at concentrations exceeding the residential RO objectives were identified as COPCs.

3.2 Sediments

Seven sediment samples were collected in Auburn, two in U.S. Drum, six in ponds north of Auburn (LHL1) and north of U.S. Drum (LHL2), and eleven just east of the Cluster Site in Indian Ridge Marsh during Phase I, II and III investigations in 1998 and 1999. Sample locations are shown in Figure 2. The samples from the Auburn area (2SED1 through 2SED7) were composite samples scraped with a hand auger along an impenetrable surface suspected to be a former parking lot.

The sediment samples were evaluated by E & E (1999b). E & E (1999b) provided several sediment criteria including the Ontario Ministry of the Environment's guidelines for the protection and management of aquatic sediment quality (Persaud et al., 1993). Based on these evaluation criteria, four COPCs, arsenic, chromium, chrysene, and lead, were selected in Auburn.

3.3 Surface Water

Surface water samples were collected during Phase I and Phase III investigations in 1998 and 1999. E & E (1999b) evaluated the surface water analytical data and used the ecological and toxicological (EcoTox) thresholds (USEPA 1996a) as the screening criteria. The analytical result of each chemical was compared to the screening criteria. If it exceeded the screening criteria, the chemical was retained as COPC. In the Auburn area, barium, iron, lead, manganese, and heptachlor are retained as COPCs. The same COPCs exceeded ecological toxicity threshold values in the pond in the southeast corner of U.S. Drum, except iron. In addition, 4,4'-DDD, 4,4'-DDE and Endrin were selected as COPCs in U.S. Drum area.

3.4 Groundwater

Groundwater data in the E & E Report (1999b) were compared to TACO Class I Groundwater ROs. Chemicals exceeding the groundwater ROs included inorganic, VOCs and SVOCs. Based upon data collected in 1998 and 1999, benzene, lead, and manganese exceed Class I groundwater ROs in virtually the entire Cluster Site. Benzene, toluene, ethylbenzene, and xylenes are primary contaminations in LC07 (Auburn), which is near the former incinerator. SVOC and inorganic contaminants (iron, lead, and manganese) were also detected in this area. Groundwater in the Auburn area to the east of LC07, southern portions of U.S. Drum (LC06 and LC05) and Unnamed Parcel (LC13) areas also contain other elevated inorganics.

3.5 Essential nutrients

Calcium, potassium, magnesium, iron and sodium were detected in all media. Since these inorganic constituents are essential nutrients for human being and information regarding adverse impacts from these inorganic constituents is not available, these essential nutrients are eliminated from further considerations as COPCs.

COPCs selected for soil, sediment, surface water and groundwater for Auburn, U.S. Drum and Unnamed Parcel of the Cluster Site are listed in Tables 3-1 through Table 3-3.

Table 3-1. Contaminants of Potential Concern in Auburn

Soil	Sediment	Surface Water	Groundwater
Antimony	Arsenic	Barium	Antimony
Arsenic	Chromium	Lead	Arsenic
Barium	Chrysene	Manganese	Barium
Beryllium	Lead	Heptachlor	Beryllium
Cadmium			Cadmium
Chromium			Chromium
Lead			Lead
Manganese			Manganese
Benzene			Mercury
Benzo(a)anthracene			Nickel
Benzo(a)pyrene			Thallium
Benzo(b)fluoranthene			Vanadium
Bis(2-chloroethyl)ether			Zinc

Table 3-1. Contaminants of Potential Concern in Alburn

Soil	Sediment	Surface Water	Groundwater
Carbon disulfide Chlorobenzene Dibenzo(a,h)anthracene Ethylbenzene Heptachlor Methylene chloride Indeno(1,2,3-cd)pyrene Tetrachloroethene Trichloroethane Toluene Total PCBs Vinyl chloride Xylenes			Benzene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(a)pyrene Bis(2-chloroethyl)ether Bis(2-ethylhexyl)phthalate Chlorobenzene Chrysene Dibenzo(a,h)anthracene 2,4-dimethylphenol Ethylbenzene Indeno(1,2,3-cd)pyrene Methylene chloride Naphthalene N-Nitrochloroethene Toluene Xylene

Table 3-2. Contaminants of Potential Concern in U.S. Drum

Soil	Sediment	Surface Water	Groundwater
Antimony Arsenic Beryllium Chromium Lead Manganese Benzene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Bis(2-ethylhexyl)phthalate Chlorobenzene Chloroform Dibenzo(a,h)anthracene 1,2-Dichloroethane Ethylbenzene Indeno(1,2,3-cd)pyrene Tetrachloroethene Toluene, Total PCBs Vinyl chloride, Xylenes	None	Barium Lead Manganese 4,4'-DDD 4,4'-DDE Endrin Heptachlor	Antimony Arsenic Barium Beryllium Cadmium Chromium Lead Manganese Mercury Nickel Vanadium Benzene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(a)pyrene Chrysene Dibenzo(a,h)anthracene Indeno(1,2,3-cd)pyrene

Table 3-3. Contaminants of Potential Concern in Unnamed Parcel

Soil	Sediment	Surface Water	Groundwater
Arsenic, Beryllium Chromium Lead Manganese Benzo(a)anthracene Benzo(a)pyrene	None	None	Arsenic Cadmium Chromium Lead Manganese Mercury Nickel Vanadium
Benzo(b)fluoranthene Benzo(k)fluoranthene Chlorobenzene Dibenzo(a,h)anthracene 1,2-Dibromo-3-Chloropropane 1,1-Dichloroethane 1,2-Dichloroethane Ethylbenzene Indeno(1,2,3-cd)pyrene alpha-BHC, Heptachlor Methylene Chloride Trichloroethene, Toluene 1,1,1-Trichloroethane, Xylenes			Zinc Benzene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(a)pyrene Bis(2-ethylhexyl)phthalate Chrysene Indeno(1,2,3-cd)pyrene

4.0 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to identify human receptors that are potentially exposed to site contaminants, to describe the exposure pathway, and the amount of the chemical intake resulting from such exposures, if any. The exposure assessment identifies the various media in which chemicals are found or transported, the location where exposure occurs, and the estimated magnitude, frequency, and duration of exposure.

4.1 Receptors

Future potential use of the Cluster Site includes use as a solar power generating station. Potential receptors for the Lake Calumet Cluster Site include on-site worker, mower, construction workers, industrial/commercial workers, and landscape worker. Specific activities of the receptors are discussed below.

- On-site Worker—Maintenance work on the solar panels.
- Mower—An adult mows the site twice a year.
- Landscape Maintenance Worker—Sows prairie grass or conducts other landscape maintenance work.
- Construction Worker—Typical construction work including grading and excavation of soils, building construction, and installment of solar panels.
- Industrial/Commercial Worker—Typical maintenance workers engaged in routine activities.

4.2 Exposure Pathway

An exposure pathway describes the course a chemical takes from the source to the receptor and is defined by four elements: 1) A source and mechanism of release; 2) An environmental transport medium; 3) A point of potential exposure with the contaminated medium; and 4) A route of exposure at the exposure point. When all these elements are present, a pathway is considered complete. Only complete exposure pathways are selected for evaluation in a risk assessment. A conceptual site model (CSM) has been developed to aid in identification of potential exposure pathways, as shown in Figure 3. The primary sources of contamination at the Cluster Site are past site activities and the existing landfills. Release mechanisms such as spills, leaks, runoff, percolation, and particulate emissions transfer contaminants to soil, air, and water. The complete and significant pathways are listed below.

- Dermal contact with groundwater by on-site workers, construction workers, and industrial/commercial workers
- Dermal contact with surface water and sediment by on-site workers, construction workers, and industrial/commercial workers
- Ingestion, inhalation (particulate and volatile emissions), and dermal contact of surface and subsurface soils by all potential receptors (It is assumed that due to construction

activities, subsurface soil will be brought up to the surface water and mixed with surface soil)

- Inhalation of groundwater by on-site workers, construction workers, and industrial/commercial workers.

4.3 Exposure Point Concentration

The Exposure Point Concentration (EPC) is defined as the concentration of a COPC that a human receptor can potentially come in contact with. EPCs were calculated using procedures described in Supplemental Guidance to RAGS: Calculating the Concentration Term (USEPA, 1992). EPCs are estimates of the arithmetic average concentration of a contaminant in a specific media. Due to uncertainties associated with estimating the true average concentration, the 95 percent upper-bound confidence limit (UCL) of the arithmetic mean concentration is used as a measure of the arithmetic average concentration.

EPCs are calculated for each of the soil areas of concern. For groundwater, each well represents an exposure point. Therefore, the highest concentration of each contaminant measured in groundwater was used as the EPC. For sediment and surface water, the maximum concentration of each COPC was used as the EPC due to insufficient data set for sediment and surface water.

The type of distribution of the data sets at each soil area of concern were first determined because equations used to calculate EPCs vary for normal and lognormal distributions. The Shapiro and Wilk's W-Test (Gilbert, 1987) was used to determine the distribution of the data sets. In all exposure areas and for all COPCs, the data sets were found to be distributed neither normally nor lognormally. Therefore, in accordance with USEPA guidance (USEPA, 1992), lognormal distribution was assumed as a default distribution.

Proxy values were assigned to non-detect samples. Although a chemical may be reported as non-detect, it may be present at a concentration below the quantitation limit. As a conservative measure, one half the value of the sample quantitation limit was used as a proxy value for non-detected samples.

EPCs then were calculated using equations presented in USEPA (1992b) for determining 95 percent UCL under lognormal distribution. Where the calculated 95 percent UCL value was higher than the maximum value in the data set, the maximum value was selected as the EPC. EPCs were calculated for each COPC using available analytical data from each exposure area. Calculation of UCL₉₅ values and EPCs for each exposure area is presented in Appendix A.

4.4 Quantification Of Exposure

Exposure dose equations consider contact rate, receptor body weight, and frequency and duration of exposure. All exposures quantified in this HHRA are normalized for time and body weight and presented in units of milligram (mg) per kilogram (kg) of body weight per day. A lifetime average daily dose (LADD) and an average daily dose (ADD) were calculated to estimate carcinogenic risks and noncarcinogenic hazards, respectively.

Equations to calculate ADD and LADD via ingestion of soil are:

$$\text{ADD (mg/kg-day)} = \text{EPC} \times \text{FI} \times \text{IRS} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{ATn}) \quad (1)$$

$$\text{LADD (mg/kg-day)} = \text{EPC} \times \text{FI} \times \text{IRS} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{ATc}) \quad (2)$$

where:

EPC, mg/kg = Exposure Point Concentration
FI, unitless = Fraction Ingested from Contaminated Source
IRS, mg/day = Soil Ingestion Rate
EF, days/year = Exposure Frequency
ED, years = Exposure Duration
CF, 10^{-6} kg/mg = Conversion Factor
BW, kg = Body Weight
ATn, days = Averaging Time for Noncarcinogens
ATc, days = Averaging Time for Carcinogens

Equations to calculate ADD and LADD via inhalation of particulates are:

$$\text{ADD (mg/kg-day)} = \text{EPCa} \times \text{IR} \times \text{ER} \times \text{EF} \times \text{ED}/(\text{BW} \times \text{ATn}) \quad (3)$$

$$\text{LADD (mg/kg-day)} = \text{EPCa} \times \text{IR} \times \text{ER} \times \text{EF} \times \text{ED}/(\text{BW} \times \text{ATc}) \quad (4)$$

where:

EPCa, mg/m^3 = Exposure Point Concentration in air = EPC/PEF
IR, m^3/hr = Inhalation Rate
ER, hrs/day = Exposure Rate
PEF, kg/m^3 = Particulate Emission Factor

Equations to calculate ADD and LADD via inhalation of volatiles in soil are:

$$\text{ADD (mg/kg-day)} = \text{EPCv} \times \text{IR} \times \text{ER} \times \text{EF} \times \text{ED}/(\text{BW} \times \text{ATn}) \quad (5)$$

$$\text{LADD (mg/kg-day)} = \text{EPCv} \times \text{IR} \times \text{ER} \times \text{EF} \times \text{ED}/(\text{BW} \times \text{ATc}) \quad (6)$$

where:

EPCv, mg/m^3 = Exposure Point Concentration in air = EPC/VF
IR, m^3/hr = Inhalation Rate
ER, hrs/day = Exposure Rate
VF, kg/m^3 = Volatilization Factor

Equations to calculate ADD and LADD via dermal contact with soils and sediment are:

$$\text{ADD (mg/kg-day)} = \text{EPC} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{ATn}) \quad (7)$$

$$\text{LADD (mg/kg-day)} = \text{EPC} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{Atc}) \quad (8)$$

where:

SA, cm² = Body Surface Area
AF, mg/cm² = Soil Adherence Factor
ABS, unitless = Dermal Adsorption Factor

Equations to calculate ADD and LADD via dermal contact with water are:

$$\text{ADD (mg/kg-day)} = \text{EPC} \times \text{SA} \times \text{PC} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{ATn}) \quad (9)$$

$$\text{LADD (mg/kg-day)} = \text{EPC} \times \text{SA} \times \text{PC} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{Atc}) \quad (10)$$

where:

PC, cm/hour = Permeability Constant
ET, hours/day = Exposure Time

Equations to calculate ADD and LADD via inhalation of water are:

$$\text{ADD (mg/kg-day)} = \text{EPC}_{\text{air}} \times \text{IR} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{ATn}) \quad (11)$$

$$\text{LADD (mg/kg-day)} = \text{EPC}_{\text{air}} \times \text{IR} \times \text{EF} \times \text{ED} \times \text{CF}/(\text{BW} \times \text{ATc}) \quad (12)$$

where:

EPC_{air} , g/m³ = Air concentration of contaminants

The calculations discussed below are based on building a model for calculating the air concentration of the groundwater contaminants. The model is described in Appendix B.

Estimation of pathway-specific exposure doses requires development of parameter values. Parameter values for exposure to different media are proposed in Tables 4-1 through 4-3.

Table 4-1
Parameter Values for Exposure to Soil at the Lake Calumet Cluster Site

Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial/ Commercial Worker
Soil Ingestion Rate ^a (mg/day)	50	480	50	480	50
Fraction Ingested ^b (unitless)	0.5	1	0.5	1	0.5
Inhalation Rate ^c (m ³ /hour)	1.1	1.7	1.1	2.8	1.1
Exposure rate ^d (hours/day)	5 ^b	8	8	8	8
Body Surface Area ^e , (cm ²)	3,300	3,300	3,300	3,300	3,300
Soil Adherence Factor ^e (mg/cm ²)	0.2	0.2	0.2	0.2	0.2
Particulate Emission Factor (kg/m ³)	8.00E-10	8.00E-09	8.00E-10	8.00E-09	8.00E-10
Exposure Frequency (days/year)	50 ^b	10 ^d	20 ^b	30 ^a	250 ^a
Exposure Duration ^a (years)	25 ^b	25 ^b	25 ^b	1 ^a	25 ^a
Body Weight ^a (kg)	70	70	70	70	70
Averaging Time for Noncarcinogens (days)	9,125	9,125	9,125	40 ^a	9,125

Notes:

^a Tiered Approach to Corrective Action Objectives, IEPA, World Wide Web, 2000.

^b Assumed based on activity patterns and time spent on-site

^c U. S. EPA, Exposure Factors Handbook, 1997. Inhalation rates based on light, moderate, and heavy activities.

^d Based on Expected working assignments at the Facility. Steve Hogan, Spire Corporation.

^e U.S.EPA Region 9.

Table 4-2
Exposure Factors for Dermal Contact with Groundwater and Surface Water

Exposure Factor	On-site Worker	Construction Worker	Industrial/ Commercial Worker
Body Surface Area ^a (cm ²)	3,300	3,300	3,300
Exposure Frequency ^b (days/year)	5	5	5
Exposure Duration ^c (years)	25	1	25
Body Weight ^d (kg)	70	70	70
Averaging Time for Noncarcinogens (days)	9,125	40 ^d	9,125

Notes:

^a U.S.EPA Region 9, www, 2000.

^b Mark Johnson, USEPA Region 5

^c Assumed value based on activity patterns

^d Tiered Approach to Corrective Action Objectives, IEPA, 2000

Table 4-3
Exposure Factors for Dermal Contact with Sediment

Exposure Factor	On-site Worker	Construction Worker	Industrial/ Commercial Worker
Body Surface Area ^a (cm ²)	3,300	3,300	3,300
Soil Adherence Factor ^a (mg/cm ²)	0.2	0.2	0.2
Exposure Frequency ^c (days/year)	5	5	5
Exposure Duration ^d (years)	25	1	25
Body Weight ^d (kg)	70	70	70
Averaging Time for Noncarcinogens (days)	9,125	40 ^c	9,125

Notes:

^a U.S.EPA Region 9, www, 2000.

^b Mark Johnson, USEPA Region 5

^c Assumed value based on activity patterns

^d Tiered Approach to Corrective Action Objectives, IEPA, 2000

Dermal adsorption factors were developed following guidance in IEPA (1994). Dermal adsorption factor of 0.01 was selected for all inorganic constituents. For Polynuclear Aromatic Hydrocarbons (PAHs), exposure doses via dermal contact were assumed to be same as those via ingestion. Dermal adsorption factors for other organics are listed in Table 4-4.

Table 4-4. Dermal Adsorption Factors

COPC	Henry's Law Constant ^a (unitless)	Octanol/Water Partition Coefficient ^a (unitless)	Dermal Adsorption Factors ^b (unitless)
Inorganics	NA	NA	0.01
Bis(2-ethylhexyl)phthalate	4.2E-06	2E+08	0.4
Tetrachloroethene	7.5E-01	4.7E+02	0.03
Trichloroethene	4.2E-01	5.1E+02	0.03
Vinyl chloride	1.1E+0	3E+01	0.03

Notes:

a EPA (1996b)

b IEPA (1994)

Permeability constant were developed in an EPA document (1992c). Permeability constant of 0.001 was selected for all inorganic constituents and the value for organic constituents are listed in Table 4-5.

Table 4-5. Permeability Constants

COPC	Permeability Constants ^c (cm/hr)
Inorganics	1.0E-03
Bis(2-ethylhexyl)phthalate	3.3E-02
Benzene	2.1E-02
Benzo(a)pyrene	1.2E+00
Benzo(a)anthracene	8.0E-01
Benzo(b)fluoranthene	1.2E+00
Chrysene	8.1E-01
Dibenzo(a,h)anthracene	2.7E+00
1,1-Dichloroethene	1.6E-02
trans-1,2-dichloroethene	1.0E-02
Indeno(1,2,3-cd)pyrene	1.9E+00
Tetrachloroethene	4.8E-02
Trichloroethene	1.6E-02
Vinyl chloride	7.3E-03

Note:

c EPA (1992c)

For VOC contaminants in groundwater, the values of their diffusion coefficients in water are needed in the model for calculating the concentration of groundwater contaminants in air. The diffusion coefficients of these VOCs are available in (EPA 1996b) and listed in Table 4-6.

Table 4-6. Diffusion Coefficients in Water (cm²/sec)

COPC	Diffusion Coefficients ^a (unitless)
Benzene	9.80E-06
Methylene Chloride	1.17E-05
Chlorobenzene	8.70E-06
Ethylbenzene	7.80E-06
Toluene	8.60E-06
Xylenes	2.20E-05

Notes:

^a EPA (1996b)

5.0 TOXICITY ASSESSMENT

5.1 Carcinogenic Health Effects Criteria And Assessment

USEPA's Carcinogenic Assessment Group has estimated the excess lifetime cancer risks associated with various levels of exposure to potential human carcinogens by developing cancer slope factors (SFs). The SFs are generally derived using conservative (health protective) assumptions. Cancer SFs developed by USEPA were used in this risk assessment. The toxicity values for potential carcinogenic effects of the COPCs are listed in Table 5-1.

Table 5-1. Toxicity Factors for COPCs^a

Chemical	Slope Factor (mg/kg-day)		Reference Dose (mg/kg-day)	
	Oral	Inhalation	Oral	Inhalation
Antimony	NA	NA	4.00E-04	NA
Arsenic	1.50E+00	NA	3.00 E-04	NA
Barium	NA	NA	7.00E-02	1.43E-04 ^b
Beryllium	NA	NA	2.00E-03	5.71E-06
Cadmium ^b	NA	NA	5.00E-04	NA
Chromium	NA	NA	1.50E+00	NA
Manganese	NA	NA	4.60E-02	1.43E-05
Mercury	NA	NA	NA	8.6E-05
Nickel	NA	NA	2.00E-02	NA
Thallium	NA	NA	8.00E-05	NA
Vanadium	NA	NA	7.00E-03 ^b	NA
Zinc	NA	NA	3.00E-01	NA
alpha-BHC	6.30E+00	6.30E+00	NA	NA
Benzene	5.50E-02	2.90E-02	NA	NA
Benzo(a)anthracene	7.30E-01 ^c	3.10E-01 ^c	NA	NA
Benzo(b)fluoranthene	7.30E-01 ^c	3.10E-01 ^c	NA	NA
Benzo(k)fluoranthene	7.30E-02 ^c	3.10E-02 ^c	NA	NA
Benzo(a)pyrene	7.30E+00 ^c	3.10E+00 ^c	NA	NA
Bis(2-Chloroethyl) Ether	1.10E+00	1.16E+00 ^d	NA	NA
Bis(2-ethylhexyl)phthalate	1.40E-02	NA	2.00E-02	NA
Chrysene	7.30E-03 ^c	3.10E-03 ^c	NA	NA
Carbon Disulfate	NA	NA	1.00E-01	2.00E-01
Chlorobenzene	NA	NA	2.00E-02	5.71E-03
Chloroform	6.10E-03	8.05E-02 ^d	1.00E-02	NA
Dibenz(a,h)anthracene	7.30E+00 ^c	3.10E+00 ^c	NA	NA
1,2-Dibromo-3-Chloropropane	1.4E+00 ^b	2.40E-3 ^b	NA	NA
1,1-Dichloroethane	NA	NA	1.00E-01 ^b	1.43E-01
2,4 -Dimethylphenol	NA	NA	2.00E-02	NA
4,4'-DDD	2.40E-01	NA	NA	NA
4,4'-DDE	3.40E-01	NA	NA	NA
Ethylbenzene	NA	NA	1.00E-01	2.86E-01

Table 5-1. Toxicity Factors for COPCs^a

Chemical	Slope Factor (mg/kg-day)		Reference Dose (mg/kg-day)	
	Oral	Inhalation	Oral	Inhalation
Heptachlor	4.50E+00	4.55E+00 ^d	5.00E-04	4.50E+00
Indeno(1,2,3-cd)pyrene	7.30E-01 ^c	3.10E-01 ^c	NA	NA
Methylene Chloride	7.50E-03	1.65E-03 ^d	6.00E-02	8.57E-01 ^b
Naphthalene	NA	NA	2.00E-02	8.57E-04
N-Nitrosodiphenylamine	4.90E-03	NA	NA	NA
Tetrachloroethene ^e	5.2E-02	2.0E-03	1.00E-02 ^d	NA
Toluene	NA	NA	2.00E-01	1.14E-01
1,1,1-Trichloroethane ^c	NA	NA	2.00E-02	6.29E-01
Trichloroethene ^c	1.1E-02	6.0E-03	NA	NA
Total PCBs	2.00E+00	2.00E+00	NA	NA
Vinyl chloride	7.2E-01	1.6E-02	3.0E-03	2.9E-02
Xylenes	2.00E+00	NA	NA	NA

Notes:

^a Source: Integrated Risk Information System (IRIS)

^b Source: Health Effects and Environmental Effects Summary Table (HEAST) as referenced in the Risk Assessment Information system (RAIS), Oak Ridge National Laboratory, 2001.

^c USEPA Region 9 Preliminary Remediation Goals, 2001

^d RAIS, Oak Ridge National Laboratory, 2001.

^e Mark Johnson, USEPA, Region 5, Personal Communication with Pinaki Banerjee, MWH, 2000.

The critical effects of each carcinogenic COPC are listed in Table 5-2.

Table 5-2. Critical Effects of Carcinogenic COPCs^a

COPCs	Effects/Target Organs
Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Chrysene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, 1,2-Dibromo-3-Chloropropane (ingestion only)	Gastrointestinal System
1,2-Dibromo-3-Chloropropane (ingestion only), Bis(2-Chloroethyl) Ether, Bis(2-ethylhexyl)phthalate, chloroform (ingestion only), DDD, DDE, Heptachlor, alpha-BHC, Methylene chloride, Tetrachloroethene, Trichloroethene, Vinyl chloride	Liver
Benzene	Circulatory System
Arsenic, Beryllium (Inhalation only), Cadmium (Inhalation only), Chromium (Inhalation only), Methylene chloride, Nickel, Vinyl chloride	Respiratory System (Lungs)

Note:

^a Tiered Approach to Corrective Action Objectives (IEPA, 1997).

5.2 Noncarcinogenic Health Effects Criteria And Assessment

Health effects for chemicals exhibiting noncarcinogenic effects are generally developed using reference doses (RfDs). The RfD is an estimate of the daily exposure to the human population that is likely to be without an appreciable risk during a lifetime. The uncertainty associated with the RfD is at least one order of magnitude and may be as high as several orders of magnitude. RfDs are expressed in units of dose (mg/kg-day) and are developed by USEPA. Table 5-1 lists the RfDs for potential noncarcinogenic effects for the COPCs.

The RfDs are selected by identifying the lowest reliable no observed effect level (NOAEL) or lowest observed adverse effect level (LOAEL) in the scientific literature, then applying a suitable uncertainty factor (UF) and a modifying factor (MF), to allow differences between the study conditions and the human exposure situation to which the RfDs are to be applied.

Each COPC exerts noncarcinogenic effect on specific target organs or mode of action. For example, mercury is known to affect central nervous systems while barium affects the circulatory or reproductive systems. In evaluating health effects due to exposure to multiple COPCs, consideration is given to the COPCs with similar target organ effect. The critical effects of each non-carcinogenic COPC are listed in Table 5-3.

Table 5-3. Critical Effects of Non-Carcinogenic COPCs

COPC	Effects/Target Organs
Cadmium (ingestion only) ^a , Chlorobenzene ^a , 1,1-Dichloroethane ^a , Ethylbenzene ^a , Toluene (ingestion only) ^a , Vanadium ^b	Kidney
2,4-Dimethylphenol ^a , Toluene ^a , Xylenes ^a , Manganese ^b , Mercury ^a	Central Nervous System
Carbon disulfide ^a , Ethylbenzene (inhalation only) ^a , Antimony, Barium ^a , 2,4-Dimethylphenol ^a , Zinc ^a	Circulatory System, Reproductive System
Naphthalene ^a , Toluene ^a , Vanadium ^b , Nickel ^b	Respiratory System
Chlorobenzene (ingestion only), Ethylbenzene, Toluene	Liver

Notes:

^a Tiered Approach to Corrective Action Objectives (IEPA, 1997).

^b Agency for Toxic Substance and Disease Registry (www.ATSDR.gov, 2001).

Toxicity factors are not currently available for lead; therefore, exposure to lead was not evaluated in this HHRA. Health effects from exposure to lead are estimated based on blood-lead levels. Blood-lead levels are estimated based on lead uptake through diet and exposure to water, soil, and air. IEPA has set a remediation objective of 400 mg/kg for lead in soil for residents and workers (IEPA, 2001). Soil locations where lead concentrations exceed 400 mg/kg were identified in Harza (2001).

6.0 RISK CHARACTERIZATION

Carcinogenic risks and noncarcinogenic hazards were characterized for each chemical, multiple chemicals within each exposure pathway, and for exposures attributable to multiple pathways, as appropriate.

6.1 Carcinogenic Risks

Quantitative human risk estimates were derived by combining the estimates of chemical intake derived in Section 4.0 (Exposure Assessment) with the health effects criteria presented in Section 5.0 (Toxicity Assessment). For potential carcinogenic chemicals, excess lifetime cancer risks (ELCR) are estimated by multiplying the cancer slope factor by the estimated daily chemical intake. The estimated ELCR represents a high-end probability that an individual could contract cancer due to exposure to the potential carcinogen under the specified exposure conditions.

ELCRs are calculated using equation (13):

$$\text{ELCR} = \text{LADD} \times \text{SF} \quad (13)$$

The intake is assumed to occur by inhalation, ingestion, and dermal contact. Therefore, additivity of effects is assumed such that the total ELCR for each chemical is obtained by summing the chemical specific risk estimated for both pathways as it relates to a specific medium. The total ELCR for exposure to multiple chemicals is expressed as:

$$\text{ELCR}_c = \text{ELCR}_1 + \text{ELCR}_2 + \text{ELCR}_3 + \dots + \text{ELCR}_i \quad (14)$$

where:

ELCR_c = Total exposure via a specific pathway
ELCR_i = ELCR estimate for the *i*th chemical

The total ELCR equals risks via all appropriate pathways, and is expressed as:

$$\text{Total ELCR} = \text{ELCR}_{e1} + \text{ELCR}_{e2} + \dots + \text{ELCR}_{ei} \quad (15)$$

where:

ELCR_{ei} = ELCR resulting from the *i*th pathway.

Carcinogenic risks are expressed as a probability for a receptor to develop cancer. A risk level of 1×10^{-6} (1E-06) represents a high-end probability of 1 in 1,000,000. USEPA generally uses a potential upper-bound risk estimate of 1E-06 as a point of departure, while a risk range of 1E-04 to 1E-06 is used as a target range for making risk management decisions. USEPA (1991) states that the upper boundary of the risk range is not a discrete line at 1E-04. A specific risk estimate around 1E-04 may be acceptable at some sites.

6.2 Noncarcinogenic Hazards

Noncarcinogenic hazards are presented as the ratio of the daily intake to the RfD or Hazard Quotient (HQ). The HQ for a specific chemical is calculated using Equation (16):

$$HQ = ADD/RfD \quad (16)$$

Chemicals that cause noncarcinogenic hazards target specific organs within human. Noncarcinogenic hazard attributable to exposure to all chemicals that affect the same organ via a specific exposure pathway is expressed as hazard index (HI) as follows:

$$HI_e = HQ_1 + HQ_2 + \dots + HQ_i \quad (17)$$

where:

HI_e = hazard index via a specific pathway
 HQ_i = hazard quotient for the i th chemical

The total noncarcinogenic hazard is calculated by:

$$\text{Total HI} = HI_{e1} + HI_{e2} + \dots + HI_{ei} \quad (18)$$

where:

HI_{ei} = hazard index via the i th pathway

The HI is useful as a reference point for gauging the potential effects of the environmental exposures to complex mixtures. HI greater than one suggests that human health effects would be possible if exposure occurred under the conditions evaluated in the assessment. In general, HI less than one is unlikely to be associated with any health risks. In this HHRA, HIs for all pathways and COPCs were summed to generate cumulative HI values.

6.3 Risk Characterization

Potential carcinogenic risks and noncarcinogenic hazards are estimated for each medium under exposure scenarios characterized in the CSM and under the assumptions used in calculating the daily doses. Carcinogenic and noncarcinogenic risks were calculated via ingestion, inhalation, and dermal contact pathways. Calculations of ADD, LADD, HI, and ELCR for Alburn, U.S. Drum and Unnamed Parcel are presented in Appendix C.

The carcinogenic risks and noncarcinogenic hazards for each of the site are summarized below.

6.3.1 Alburn

The carcinogenic risks and noncarcinogenic hazards for exposure to each of the media at Alburn area are presented in Table 6-1.

Table 6-1. Carcinogenic Risk and Noncarcinogenic Hazards for Each Media at Alburn

	On-site worker	Construction Worker	Industrial/Commercial Worker	Mower	Landscape Worker
Soil					
Total ELCR	5E-06	2E-05	2E-05	3E-06	2E-06
Total HI	2E-02	4E+00	2E-01	4E-02	8E-01
Groundwater					
Total ELCR	8E-07	3E-08	8E-07	NA	NA
Total HI	1E-02	1E-01	1E-02	NA	NA
Surface Water					
Total ELCR	3E-09	1E-10	3E-09	NA	NA
Total HI	4E-05	4E-04	4E-05	NA	NA
Sediment					
Total ELCR	2E-07	9E-09	2E-07	NA	NA
Total HI	1E-03	1E-02	1E-03	NA	NA

In Table 6-1, the shaded cells indicate that the total ELCR exceeds 1.0E-06 or total HI exceeds 1.0. Risks are primarily due to exposure to soil. Risk due to exposure to sediment, surface water and groundwater are insignificant. The carcinogenic risks represented by ELCR exceed 1E-06 for all receptors. The noncarcinogenic risks represented by HI are equal to or exceed 1E+00 for construction workers. COPC that contributed significantly to carcinogenic risks (risks exceeding 1E-06) and the corresponding receptors are listed in Table 6-2. For noncarcinogenic hazards exceeding 1, the primary COPC is toluene and the corresponding receptor is construction worker.

Table 6-2. Summary of Carcinogenic COPCs at Alburn

Carcinogenic COPCs	Receptors
Arsenic	Industrial/Commercial Worker, Mower
Benzene	Industrial/Commercial Worker
Benzo(a)pyrene	Industrial/Commercial Worker, Mower
Total PCBs	Industrial/Commercial Worker
Vinyl Chloride	Industrial/Commercial Worker, Mower

6.3.2 U.S. Drum

At the U.S. Drum area, no COPCs were selected in sediment samples. Therefore, only soil, surface water and groundwater are considered as the exposure media in the U.S. Drum. The carcinogenic risks and noncarcinogenic hazards for exposure to each media are presented in Table 6-3.

Table 6-3. Carcinogenic Risk and Noncarcinogenic Hazards for Each Media at U.S. Drum

	On-site worker	Construction Worker	Industrial/Commercial Worker	Mower	Landscape Worker
Soil					
Total ELCR	1E-05	3E-06	5E-05	3E-05	4E-06
Total HI	1E-02	9E-01	6E-02	3E-02	2E-01
Groundwater					
Total ELCR	4E-07	1E-08	4E-07	NA	NA
Total HI	3E-03	4E-02	5E-04	NA	NA
Surface Water					
Total ELCR	9E-10	4E-11	9E-10	NA	NA
Total HI	2E-05	3E-04	4E-06	NA	NA

In Table 6-3, the shaded cells indicate that the total ELCR exceeds 1.0E-06. Risks are primarily due to exposure to soil. Risk due to exposure to sediment, surface water and groundwater are insignificant. The carcinogenic risks exceed 1E-06 for all the receptors. The noncarcinogenic risks are less than 1E+00 for all the receptors. COPCs that contributed significantly (risk exceeding 1E-06) to carcinogenic risks and the corresponding receptors are listed in Table 6-4.

Table 6-4. Summary of Carcinogenic COPCs at U.S. Drum

Carcinogenic COPCs	Receptors
Arsenic	Industrial/Commercial Worker, Mower
Benzo(a)pyrene	On-site Worker, Industrial/Commercial Worker, Mower
Dibenz(a,h)anthracene	On-site Worker, Industrial/Commercial Worker
Total PCBs	On-site Worker, Industrial/Commercial Worker, Mower, Landscape Worker

6.3.3 Unnamed Parcel

In the Unnamed Parcel area, COPCs are distributed in soil and groundwater media. No COPCs were selected in surface water and sediment samples. The carcinogenic risks and noncarcinogenic hazards for exposure to soil and groundwater at the Unnamed Parcel area are presented in Table 6-5.

Table 6-5. Carcinogenic Risk and Noncarcinogenic Hazards for Soil and Groundwater at Unnamed Parcel

	On-site worker	Construction Worker	Industrial/Commercial Worker	Mower	Landscape Worker
Soil					
Total ELCR	3E-06	1E-06	2E-05	1E-05	1E-06
Total HI	1E-02	6E-01	5E-02	2E-02	1E-01
Groundwater					
Total ELCR	2E-07	9E-09	2E-07	NA	NA
Total HI	4E-04	4E-03	4E-04	NA	NA

In Table 6-5, the shaded cells indicate that the total ELCR exceeds $1.0E-06$. Risks are primarily due to exposure to soil. Risk due to exposure to sediment, surface water and groundwater are insignificant. The carcinogenic risks exceed $1E-06$ for industrial/commercial workers, mowers, and on-site workers. The noncarcinogenic risks are less than $1E+00$ for all the receptors. COPCs that contributed significantly (risk exceeding $1E-06$) to carcinogenic risks and the corresponding receptors are listed in Table 6-6.

Table 6-6. Summary of Carcinogenic COPCs at Unnamed Parcel

Carcinogenic COPCs	Receptors
Arsenic	Industrial/Commercial Worker, Mower
Benzo(a)pyrene	Industrial/Commercial Worker, Mower

7.0 UNCERTAINTIES

Uncertainties are introduced at various points throughout the HHRA process, a product of the uncertainties associated with all data and the assumptions used. Specific areas of uncertainty are related to data evaluation; exposure assessment; toxicity assessment; and risk characterization are discussed in this section.

7.1 Exposure Assessment

The exposure estimates used in this HHRA are conservative and, to be health protective, are designed to overestimate actual risks when there is an uncertainty. Several of the factors contributing to uncertainty result in probable overestimation of exposure:

- The directed (biased) nature of the sampling plan, which focuses on the most contaminated parts of the site;
- The use of maximum concentrations as EPCs for groundwater, sediment and surface water data available from multiple sampling rounds;
- The use of steady state assumptions for the source concentration estimates (i.e. the COPC concentrations are not subject to decrease due to attenuation and/or degradation for the duration of the exposure period);
- The exposure parameter values for receptors.

Another factor which could lead to over or underestimation of exposures is the use of one-half MDL to estimate the nondetects.

7.2 Toxicity Assessment

Basic uncertainties underlying the assessment of the toxicity of a chemical include:

- Uncertainties involved in extrapolating from underlying scientific studies to the exposure scenarios being evaluated, including variable responses to chemical exposures in human and species and between species.

These uncertainties could either under- or overestimate the true toxicity of chemicals present. The toxicity assessment process compensates for these uncertainties through the use of uncertainty factors and modifying factors when deriving RfDs for noncarcinogens, and the use of 95% confidence limit when deriving the SFs for carcinogens.

7.3 Risk Characterization

When discussing uncertainties associated with the overall risk assessment, the cumulative effect of conservative assumptions throughout the process and the likelihood of the exposures

postulated and estimated in the exposure assessment actually occurring should be considered. The cumulative effect of conservative assumptions may substantially overestimate true risks. The nature of risk estimation process ensures that the true risks are more likely to be overestimated than underestimated.

8.0 CONCLUSIONS

The HHRA was conducted to assess the potential adverse human health effects that could occur due to exposure to contaminants in each media (soil, sediment, surface water and groundwater) at the Cluster Site. The exposure and risk assessment of carcinogenic risk and noncarcinogenic hazard are performed separately at three areas in the Cluster site, which are Alburn, U.S. Drum and Unnamed Parcel. Carcinogenic risks and noncarcinogenic hazard due to exposure to contaminants in each media at the three areas are summarized below:

In Alburn area, exposures to soil, sediment, surface water and groundwater are discussed. Risk due to exposure to contaminants in soil exceeds carcinogenic risk of $1E-06$ for all receptors. COPCs that contributed significantly to carcinogenic risks (exceeding $1E-06$) are arsenic, benzene, benzo(a)pyrene, total PCBs and vinyl chloride. For noncarcinogenic hazard, among all receptors, the exposure to contaminants in soil for construction worker exceeds HI of $1E+00$ and the primary contributed COPC is toluene. The exposure to contaminants in other media (including sediment, surface water and groundwater) do not exceed carcinogenic risk of $1E-06$ or noncarcinogenic hazard of 1 for all receptors.

In U. S. Drum area, no COPCs were selected in sediment samples. Therefore, only exposure to contaminants in soil, surface water and groundwater are discussed. The carcinogenic risk exceeds $1E-06$ in soil for all receptors and the primary COPCs are arsenic, benzo(a)pyrene, dibenz(a,h)anthracene and total PCBs. No noncarcinogenic hazard exceeds 1 for all receptors due to exposure to contaminants in soil. The exposures to contaminants in surface water and groundwater do not exceed carcinogenic risk of $1E-06$ or noncarcinogenic hazard of 1 for all receptors.

In Unnamed Parcel area, no COPCs were selected in sediment and surface water. The carcinogenic risk due to exposure to contaminants in soil exceeds $1E-06$ for on-site worker, industrial/commercial worker and mower. The primary COPCs in soil for carcinogenic risk are arsenic and benzo(a)pyrene. No noncarcinogenic hazard exceeds 1 for all receptors due to exposure to contaminants in soil. The exposures to contaminants in groundwater do not exceed carcinogenic risk of $1E-06$ or noncarcinogenic hazard of 1 for all receptors.

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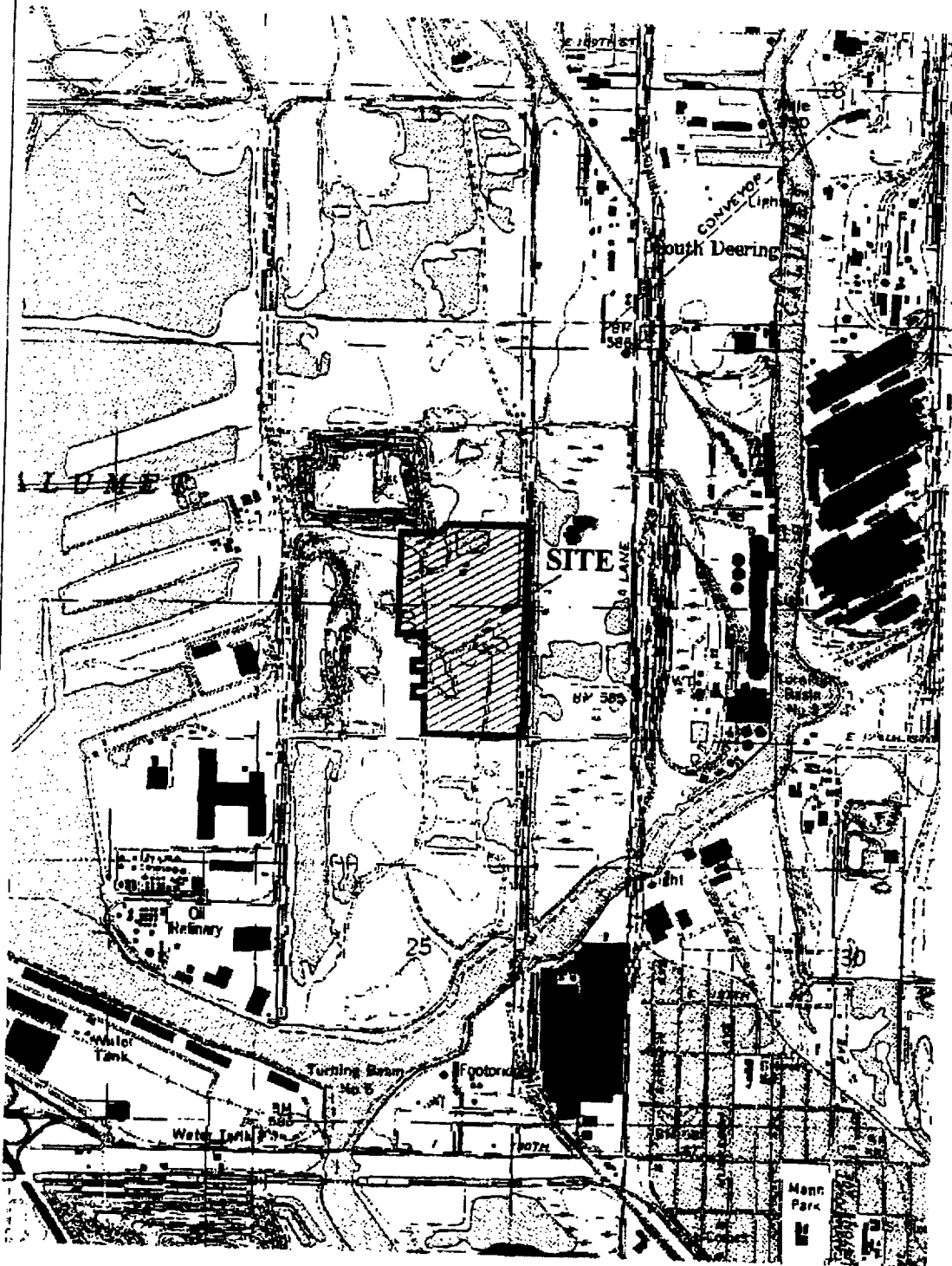
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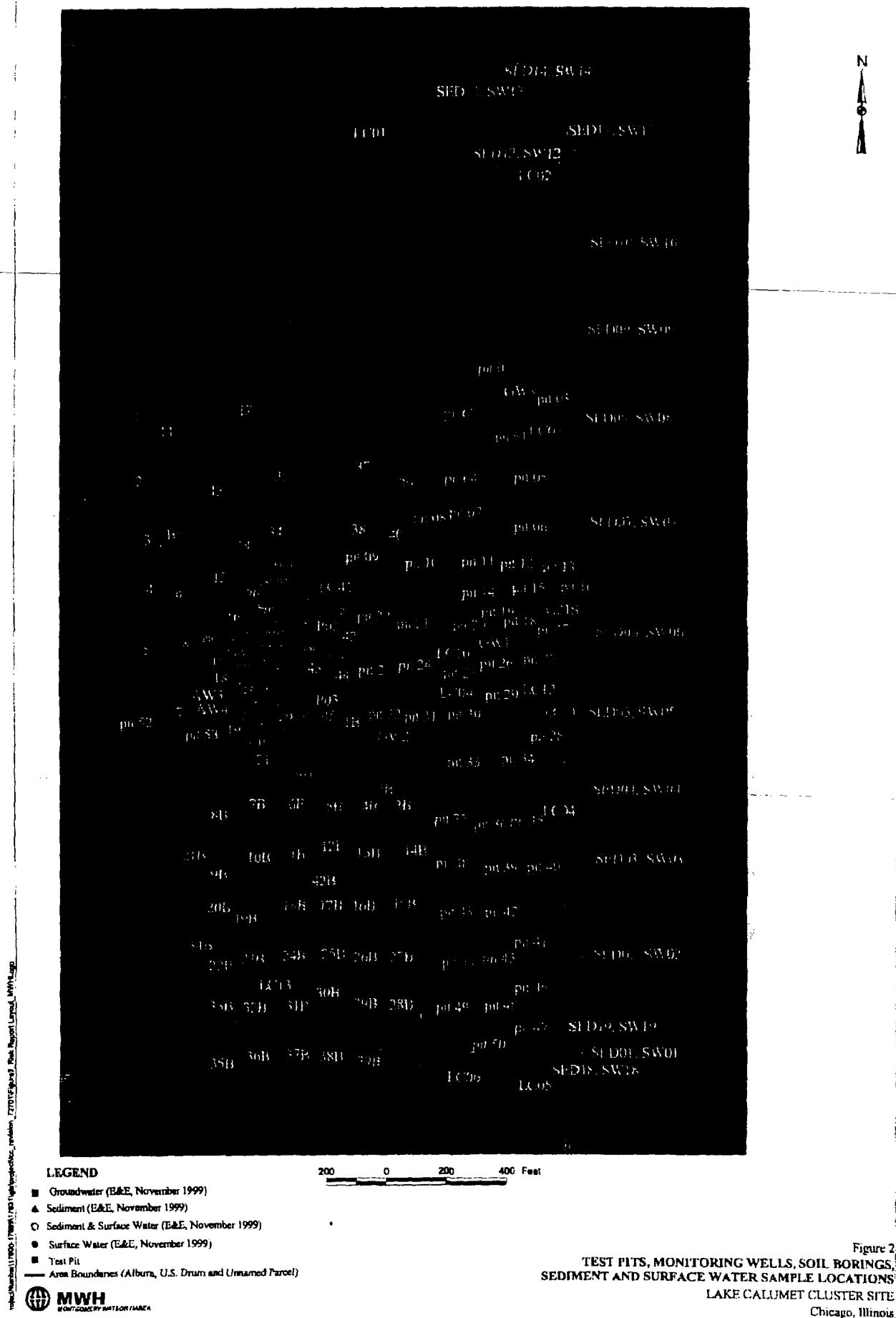


SOURCE:
USGS Lake Calumet, Illinois,
7.5 Minute Quadrangle, 1965, Revised 1997

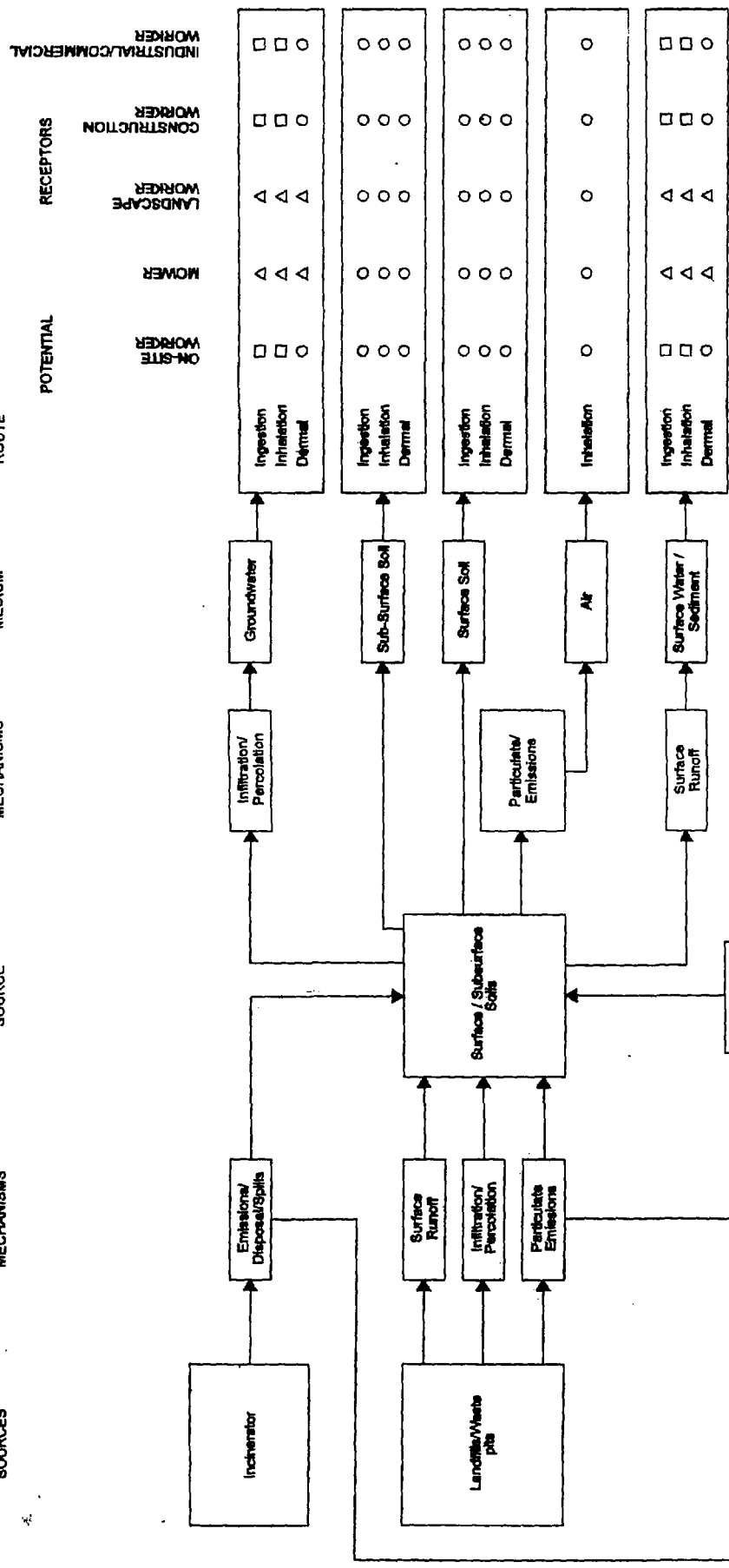


MWH
MONTGOMERY WATSON HARRIS

Figure 1
SITE LOCATION MAP
LAKE CALUMET CLUSTER SITE
Chicago, Illinois



PRIMARY SOURCES PRIMARY RELEASE MECHANISMS SECONDARY SOURCE SECONDARY RELEASE MECHANISMS EXPOSURE MEDIUM EXPOSURE ROUTE



LEGEND:
 ○ Pathway Complete and Significant
 □ Pathway Complete but Insignificant
 △ Pathway Incomplete

Figure 3
 CONCEPTUAL SITE MODEL
 LAKE CALUMET CLUSTER SITE
 Chicago, Illinois



APPENDIX A

UCL₉₅ and EPCs of Soil COPCs

Table 1. UCL 95 and EPCs For Soil COPCs in Albarn (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DefFreq	StdDev	Std	hStat	UCL	InUCL	EPC
1,2,4-Trichlorobenzene	385000	3	8651.99	44187.423	5.59913	2.8781027	90	73	19	2.90	1.665	4.8	16406	73586.4	73586
1,2-Dibromo-3-Chloropropane	385000	4.5	8581.22	44194.76	5.44861	2.834513	90	60	33	2.65	1.665	4.44	16336	35187.2	35187
1,2-Dichlorobenzene	385000	1	8441	44214.881	5.44861	2.8241714	90	80	11	2.80	1.665	4.66	16200	50586.1	50586
1,2-Dichloroethane	385000	4.5	8481.46	44211.241	5.50256	2.7939762	90	89	11	2.80	1.665	4.66	16239	48321.8	48322
1,4-Dichlorobenzene	385000	1	8401.54	44222.645	5.30224	2.7989062	90	64	29	2.80	1.665	4.66	16162	42682.5	42683
2,2'-Oxybis(1-Chloropropane)	8800	150	841.167	1397.7496	6.05268	1.0160839	90	77	14	1.00	1.665	2.31	1086	913.483	913.48
2,4,6-Trichlorophenol	22000	120	2070.06	3494.8716	6.91583	1.0514441	90	80	11	1.05	1.665	2.36	2683	2279.52	2279.5
2,4,6-Trichlorophenol	8800	150	834.833	1401.6117	6.02188	1.0330619	90	81	10	1.05	1.665	2.36	1081	910.509	910.51
2,4-Dichlorophenol	8800	150	806.167	1395.9903	5.9825	1.0193097	90	82	9	1.00	1.665	2.31	1051	855.04	855.04
2,4-Dimethylphenol	51000	27	1370.16	5469.9041	5.98959	1.2404864	90	61	32	1.25	1.665	2.58	2330	1209.83	1209.8
2,4-Dinitrophenol	22000	375	2775.27	4182.8211	7.20776	1.0875845	91	49	46	1.10	1.665	2.42	3505	3216.68	3216.7
2,4-Dinitrotoluene	8800	120	846.978	1429.4892	6.01354	1.0488653	91	78	14	1.05	1.665	2.36	1096	920.221	920.22
4-Methylphenol	29000	23	1400.39	3486.7151	6.11746	1.3784106	90	38	58	1.40	1.665	2.76	2012	1756.04	1756
4-Nitroaniline	22000	375	2178.42	3620.2585	6.96337	1.0461832	92	78	15	1.05	1.664	2.36	2807	2367.36	2367.4
4-Nitrophenol	22000	375	2192.72	3557.896	7.00871	1.0295713	90	72	20	1.05	1.665	2.36	2817	2431.74	2431.7
Acenaphthene	130000	22	3805.99	15719.637	6.44467	1.5818984	91	10	89	1.60	1.665	3.01	6549	3632.03	3632
Acenaphthylene	25000	21	1324.14	3537.4719	5.98336	1.3857354	90	17	81	1.40	1.665	2.76	1945	1554.62	1554.6
Acetone	385000	5	9018.43	44343.553	6.20465	2.3506628	90	50	44	2.35	1.665	4.02	16800	21354.1	21354
Acetophenone	8800	20	790.344	1416.8243	5.79498	1.22196	90	71	21	1.20	1.665	2.53	1039	961.652	961.65
Alidin	150	0.41	6.24092	17.057114	0.82959	1.16978	87	59	32	1.15	1.665	2.47	9.286	6.20528	6.2053
alpha-BHC	170	0.077	8.82587	21.319347	0.99986	1.4246565	86	36	58	1.45	1.666	2.82	12.65	11.5949	11.595
alpha-Chloroane	2000	0.29	38.7469	225.23413	1.20939	1.5449323	87	33	62	1.55	1.665	2.94	78.96	18.0544	18.054
alpha-Endosulfon	37	0.8	4.39943	6.6374882	0.78023	1.0545876	87	62	29	1.05	1.665	2.36	5.585	4.97673	4.9767
Aluminum	35900000	2670000	1.1E+07	5631594.4	16.093	0.4616525	94	0	100	0.45	1.664	1.84	1E+07	1.2E+07	1E+07
Anthracene	56000	31	2562.97	7212.5983	6.62221	1.4710709	91	7	92	1.45	1.665	2.82	3821	3434.54	3434.5
Anthromy	1020000	360	26579.8	130973.14	8.25393	1.4211826	94	5	95	1.40	1.664	2.76	49056	15845.5	15846
Arochlor 1016	440	15	63.7529	95.420829	3.55252	0.9285622	85	76	11	0.95	1.666	2.26	80.99	67.5047	67.505
Arochlor 1221	900	31	128.876	192.45476	4.25996	0.9261603	85	76	11	0.95	1.666	2.26	163.6	136.567	136.57
Arochlor 1232	440	15	63.7529	95.420829	3.55252	0.9285622	85	76	11	0.95	1.666	2.26	80.99	67.5047	67.505
Arochlor 1248	5900	15	182.094	679.2844	3.82207	1.278648	85	69	19	1.30	1.666	2.64	304.8	149.588	149.59
Arochlor 1254	10000	15	504.099	1293.8224	4.57624	1.7352889	85	44	48	1.75	1.666	3.2	737.8	802.498	802.5
1,1,1-Trichloroethane	7900	15	498.142	1265.0058	4.53002	1.7123324	88	47	47	1.70	1.665	3.14	722.7	714.659	714.66
1,1,1-Trichloroethane	385000	1	14580.1	66902.384	5.50815	2.9414263	90	81	10	2.95	1.665	4.88	26320	85319.5	85320
1,1,2,2-Tetrachloroethane	385000	4.5	8485.34	44210.505	5.58713	2.7056453	90	81	10	2.70	1.665	4.52	16243	37890.5	37891
1,1,2-Trichloro-1,2,2-Trifluoroethane	385000	4.5	8503.08	44207.494	5.54092	2.791776	90	87	3	2.80	1.665	4.66	16261	49850.1	49850
1,1,2-Trichloroethane	385000	4.5	8483.96	44210.765	5.51631	2.7923738	90	89	11	2.80	1.665	4.66	16242	48733.5	48734
1,1-Dichloroethane	385000	2	8385.11	44203.45	5.48578	2.8038879	90	78	13	2.80	1.665	4.66	16142	49094.2	49094
1,1-Dichloroethane	385000	4.5	8485.04	44210.564	5.55633	2.7436898	90	85	6	2.75	1.665	4.59	16243	42379.9	42380
2,6-Dinitrotoluene	8800	150	825.165	1394.299	6.00603	1.0317168	91	83	9	1.05	1.665	2.36	1069	893.364	893.36
2-Chloronaphthalene	8800	150	834.611	1401.6265	6.02188	1.032457	90	81	10	1.05	1.665	2.36	1081	909.803	909.8
2-Chlorophenol	8800	150	821.556	1404.6725	5.99107	1.0340265	90	85	6	1.05	1.665	2.36	1068	883.981	883.98

Table 1. UCL 95 and EPCs For Soil COPCs in Auburn (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	Defreq	StdDev	Std	hStd	UCL	InUCL	EPC
2-Hexanone	385000	2	9866.66	45519.462	5.98685	2.7440429	86	47	45	2.75	1.665	4.59	18042	67314	67314
2-Methylnaphthalene	95000	26	4710.24	13548.611	6.72061	1.8362894	90	2	98	1.85	1.665	3.33	7088	8564.56	8564.6
2-Methylphenol	8800	22	828.911	1504.4244	5.79245	1.2402673	90	62	31	1.25	1.665	2.58	1093	993.038	993.04
2-Nitroaniline	22000	375	2067.22	3497.3904	6.91629	1.0384581	90	84	7	1.05	1.665	2.36	2681	2242.52	2242.5
2-Nitrophenol	8800	150	828.278	1402.9846	6.00647	1.0345437	90	83	8	1.05	1.665	2.36	1074	898.299	898.3
3,3'-Dichlorobenzidine	8800	170	1076.59	1629.3154	6.33119	1.0235727	88	46	48	1.00	1.665	2.31	1366	1221.82	1221.8
3-Nitroaniline	22000	375	2106.59	3566.6421	6.91908	1.048116	91	84	8	1.05	1.665	2.36	2729	2273.72	2273.7
4,6-Dinitro-2-methylphenol	22000	375	2278.96	3661.7291	7.0329	1.0489486	91	71	22	1.05	1.665	2.36	2918	2550.59	2550.6
4-Bromophenyl phenyl ether	8800	150	840.11	1397.0405	6.07049	1.0347908	91	78	14	1.05	1.665	2.36	1104	956.61	956.61
4-Chloro-3-methylphenol	8800	150	820.22	1397.1349	5.99484	1.0327634	91	83	9	1.05	1.665	2.36	1064	884.607	884.61
4-Chloroaniline	8800	150	890.333	1515.196	6.03347	1.0626106	90	77	14	1.05	1.665	2.36	1156	957.14	957.14
4-Chlorophenyl phenyl ether	8800	150	830.278	1402.3999	6.01418	1.0302317	90	82	9	1.05	1.665	2.36	1076	900.252	900.25
Arochlor 1260	5500	15	182.186	620.4437	3.95139	1.2975059	86	64	26	1.30	1.666	2.64	293.6	174.988	174.99
Arsenic	151000	3000	15166	20218.46	9.32004	0.677644	94	0	100	0.70	1.664	2.03	18636	16186.5	16187
Atrazine	8800	150	871.111	1431.1604	6.06809	1.040135	90	75	17	1.05	1.665	2.36	1122	962.29	962.29
Borflum	2840000	28900	305560	397103.09	12.1246	0.9953381	94	0	100	1.00	1.664	2.31	4E+05	383858	383858
Benzaldehyde	8800	40	703.589	1212.9062	5.84742	1.0407002	90	78	13	1.05	1.665	2.36	916.4	772.304	772.3
Benzene	385000	2	9341.45	43131.672	5.67872	2.8902396	90	34	62	2.90	1.665	4.8	16910	83033.3	83033
Benzo(a)anthracene	67000	30	3384.92	8317.2912	7.00863	1.4739825	90	5	94	1.45	1.665	2.82	4844	5092.73	5092.7
Benzo(a)pyrene	37000	22	2756.36	5944.6242	6.87294	1.4717994	90	4	96	1.45	1.665	2.82	3799	4429.79	4429.8
Benzo(b)fluoranthene	72000	31	4031.88	9881.1403	7.1782	1.4555737	90	4	96	1.45	1.665	2.82	5766	5841.66	5841.7
Benzo(g,h,i)perylene	26000	31	1938.93	3937.8977	6.62987	1.347698	91	13	86	1.35	1.665	2.7	3370	2977.89	2977.9
Benzo(k)fluoranthene	40000	34	2377.51	5690.6004	6.72196	1.338636	89	38	57	1.55	1.665	2.94	3578	3016.64	3016.6
Benzo(k)fluoranthene	59000	23	2345.63	6981.9133	6.33121	1.5461681	90	5	94	1.35	1.665	2.7	2630	2762.2	2762.2
Benzyl Butyl Phthalate	8400	350	1401.06	1194.1159	7.02269	0.6279639	94	0	100	0.65	1.664	1.99	1606	1554.88	1554.9
Beryllium	180	0.074	7.27133	21.950143	0.79495	1.2684168	86	57	34	1.25	1.666	2.58	11.21	7.05928	7.0593
beta-BHC	44	0.21	5.42733	8.1538103	1.07406	1.0390765	86	48	44	1.05	1.666	2.36	6.892	6.5533	6.5533
beta-Endosulfan	26000	21	1150	3206.2108	5.84934	1.4532498	90	15	83	1.45	1.665	2.82	1713	1540.46	1540.5
Bis(2-Chloroethoxy) Methane	8800	150	821.056	1405.5627	5.98337	1.0407552	90	86	4	1.05	1.665	2.36	1068	884.832	884.83
Bis(2-Chloroethyl) Ether	8800	150	819.833	1405.6918	5.98243	1.0384316	90	87	3	1.05	1.665	2.36	1056	881.356	881.36
Bis(2-Ethylhexyl) Phthalate	93000	56	7989.29	15478.653	7.55462	1.8194062	90	42	53	1.80	1.665	3.27	10705	18764.5	18764
Bromodichloromethane	385000	4	8484.72	44210.627	5.51428	2.7978532	90	89	1	2.80	1.665	4.66	16243	49519.3	49519
Bromofarm	385000	4.5	8417.4	43968.737	5.58396	2.7509219	91	85	7	2.75	1.665	4.59	16089	44267	44267
Bromomethane	385000	3	8485.62	44210.451	5.58235	2.7210155	90	82	9	2.70	1.665	4.52	16244	39605.8	39606
Cadmium	142000	110	5484.73	16800.504	7.1915	1.5638154	92	13	86	1.55	1.664	2.94	8400	7310.07	7310.1
Calcium	346000000	4870000	9.7E+07	71018952	18.1489	0.7394294	92	0	100	0.75	1.664	2.07	1E+08	1E+08	1E+08
Caprolactam	8800	38	965.244	1557.2586	6.12788	1.1051479	90	59	34	1.10	1.665	2.42	1239	1120.5	1120.5
Carbazole	35000	20	1444.92	4076.0526	6.11826	1.3862051	90	17	81	1.40	1.665	2.76	2160	1780.53	1780.5
Carbon disulfide	385000	1	8383.14	44183.132	5.37697	2.9707524	90	61	32	2.98	1.665	4.88	16136	82852.8	82853
Chlorobenzene	385000	3	6597.43	40850.408	5.46848	2.7643624	90	72	20	2.75	1.665	4.59	13766	41504.7	41505
Chloroethane	385000	4.5	8839.02	44166.354	5.74887	2.6979763	90	60	33	2.90	1.665	4.8	16589	91443	91443

Table 1. UCL 95 and EPCs For Soil COPCs in Alburn (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDel	Defreq	StdDev	Stal	hStal	UCL	InUCL	EPC
Chloromethane	385000	4.5	8484.81	44210.609	5.52755	2.7802586	90	88	2	2.80	1.665	4.66	16243	47364.2	47364
Chromium	1730000	13200	198441	317243.17	11.3665	1.2441442	94	0	100	1.25	1.664	2.58	3E+05	261271	261271
Chrysene	74000	31	3620.01	8893.4731	7.14024	1.4450911	90	4	96	1.45	1.665	2.82	5181	5521.9	5521.9
cis-1,2-Dichloroethane	385000	1	7456.41	41808.029	5.51848	2.8236627	90	63	30	2.80	1.665	4.66	14793	54155.1	54155
Cobalt	84200	235	9814.35	11612.76	8.77534	1.0445352	93	3	97	1.05	1.664	2.36	11818	14442.9	14443
Copper	5010000	14000	251135	596920.56	11.5145	1.2135896	94	0	100	1.20	1.664	2.53	4E+05	287401	287401
Cyanide	218000	90	6457.61	30331.153	7.13503	1.302213	90	3	97	1.30	1.665	2.64	11780	4218.96	4219
Cyclohexane	385000	1	8504.43	44207.213	5.60298	2.7625858	90	78	13	2.75	1.665	4.59	16262	47206.8	47207
dieldrin-BHC	36	0.16	3.80581	5.960652	0.65554	1.0604652	86	50	42	1.05	1.666	2.36	4.876	4.43434	4.4343
Di-N-Butyl Phthalate	34000	16	1090.37	3732.502	5.53708	1.5743346	89	19	79	1.55	1.665	2.94	1749	1437.35	1437.4
Di-N-Octylphthalate	8800	21	1103.63	1760.1662	6.21719	1.195133	87	36	69	1.20	1.665	2.53	1418	1417.7	1417.7
Dibenz(a,h)Anthracene	11000	22	1049.79	1859.4188	5.99569	1.3667014	90	18	80	1.35	1.665	2.7	1376	1511.46	1511.5
Dibenzofuran	77000	23	2315.12	8622.7179	6.31194	1.4950343	91	16	82	1.60	1.665	2.88	3820	2653.2	2653.2
Dichlorodifluoromethane	385000	4.5	9199.85	44561.866	5.58713	2.837398	90	81	10	2.85	1.665	4.73	17019	62111.8	62112
Dieldrin	290	0.45	22.3455	39.249834	2.0194	1.5158534	89	16	82	1.50	1.665	2.88	29.27	37.8581	37.858
Diethyl Phthalate	8800	30	813.1	1427.326	5.91405	1.258529	90	70	22	1.15	1.665	2.47	1064	936.957	936.96
Dimethyl Phthalate	8800	150	817.5	1395.4622	6.00567	1.019485	90	81	10	1.00	1.665	2.31	1062	875.28	875.28
Endosulfan sulfate	190	0.26	9.87663	22.463489	1.41515	1.1811628	89	41	64	1.20	1.665	2.53	13.84	11.3666	11.367
Endrin	280	0.18	13.7189	34.79132	1.53757	1.3364549	89	39	56	1.35	1.665	2.7	19.86	16.699	16.699
Endrin acetate	350	0.5	14.0882	38.832268	1.68537	1.2121617	89	27	70	1.20	1.665	2.53	20.94	15.5854	15.585
Endrin ketone	78	0.37	7.30784	11.894515	1.34374	1.011623	88	54	39	1.00	1.665	2.31	9.419	8.10917	8.1092
Ethylbenzene	500000	1	97775.2	558622.88	6.59097	3.6171507	90	17	81	3.60	1.665	5.83	2E+05	4723348	5E+06
Fluoranthene	230000	22	8491.31	26801.327	7.62817	1.6879303	91	3	97	1.70	1.665	3.14	13168	14924	14924
Fluorene	96000	28	3036.19	10862.73	6.64781	1.4792364	90	9	90	1.50	1.665	2.88	4946	3617.78	3617.8
gamma-BHC	220	0.12	6.12736	23.740534	0.7709	1.0957285	87	47	46	1.10	1.665	2.42	10.37	5.24161	5.2416
gamma-Chlordane	520	0.57	21.4013	64.469069	1.68832	1.4880237	90	39	57	1.50	1.665	2.88	32.71	25.2757	25.276
Heptachlor	64	0.9	3.91701	7.8075556	0.71512	0.9342149	87	70	20	0.95	1.665	2.26	5.311	3.97001	3.97
Heptachlor epoxide	110	0.17	10.5927	18.635213	1.31749	1.4714803	88	28	68	1.45	1.665	2.82	13.9	17.2037	17.204
Hexachlorobenzene	8800	150	841.222	1399.8861	6.03728	1.0321687	90	79	12	1.05	1.665	2.36	1087	923.584	923.58
Hexachlorobutadiene	8800	150	821.056	1405.5627	5.98337	1.0407552	90	86	4	1.05	1.665	2.36	1068	884.832	884.83
Hexachlorocyclopentadiene	8800	150	921.778	1445.3934	6.1374	1.0458963	90	66	27	1.05	1.665	2.36	1175	1039.07	1039.1
Hexachloroethane	8800	150	814.333	1407.2126	5.96797	1.039895	90	88	2	1.05	1.665	2.36	1061	870.341	870.34
Indeno(1,2,3-CD)pyrene	24000	20	1874.54	3382.9666	6.61401	1.3878428	90	6	93	1.40	1.665	2.76	2468	2931.22	2931.2
Iron	406000000	7970000	5.2E+07	55034274	17.4575	0.738418	92	0	100	0.75	1.664	2.07	6E+07	5.9E+07	6E+07
Isophorone	8800	33	801.7	1439.1721	5.90753	1.0846488	90	73	19	1.10	1.665	2.42	1054	874.358	874.36
Isopropylbenzene	170000	1	5898.31	20907.349	5.64583	2.9465667	90	37	59	2.95	1.665	4.88	9567	99670.7	99671
Lead	6730000	15300	549498	955779.1	12.4175	1.2874305	94	0	100	1.30	1.664	2.64	7E+05	805069	805069
Magnesium	52300000	883000	1.9E+07	10896983	16.5443	0.7545205	94	0	100	0.75	1.664	2.07	2E+07	2.4E+07	2E+07
Manganese	40500000	156000	3173261	5858092.5	14.1261	1.2088966	92	0	100	1.20	1.664	2.53	4E+06	3901427	4E+06
Mercury	3800	15	411.33	586.57617	5.44968	1.0294423	94	2	98	1.05	1.664	2.36	512	508.554	508.55
Methoxychlor	300	1.8	42.8978	65.424071	2.99067	1.120287	91	56	38	1.10	1.665	2.42	54.31	49.5731	49.573

Table 1. UCL 95 and EPCs For Soil COPCs in Alburn (unit: ug/kg)

Andlyte Name	Max Value	Mln Value	Average	Standard Deviatlon	In Ave.	In Standard Deviatlon	Number	NonDel	DefFreq	StdDev	Std	hStd	UCL	InUCL	EPC
Methyl acetate	385000	5	8497.97	44208.657	5.55845	2.748912	90	84	7	2.75	1.665	4.59	16256	43192.9	43193
Methyl ethyl ketone	385000	4	8579.39	44205.664	5.66349	2.7017626	90	76	16	2.70	1.665	4.52	16336	40394.8	40395
Methyl isobutyl ketone	385000	4	8575.61	44195.265	5.66039	2.783009	90	74	18	2.80	1.665	4.66	16331	54583.1	54583
Methylcyclohexane	385000	1	12217.3	56967.219	5.63259	2.9173374	90	42	53	2.90	1.665	4.8	22214	86972.6	86973
Methylene chloride	400000	2	8884.02	47037.78	5.65414	2.785822	90	35	61	2.80	1.665	4.66	17138	54745.5	54745
N-Nitrosodl-N-Propylamine	8800	150	901.611	1485.93	6.07579	1.0560201	90	74	18	1.05	1.665	2.36	1162	989.937	989.94
N-Nitrosodiphenylamine	8800	150	864.663	1412.3376	6.07867	1.0276602	89	67	25	1.05	1.665	2.36	1114	958.47	958.47
Naphthalene	670000	24	19992.9	85370.447	7.61978	2.0881689	90	1	99	2.10	1.665	3.67	34973	36782.6	36783
Nickel	568000	10500	56988.3	88886.58	10.5223	0.7745366	94	0	100	0.80	1.664	2.11	72242	59392	59392
Nitrobenzene	8800	150	821.056	1405.5627	5.98337	1.0407552	90	86	4	1.05	1.665	2.36	1068	884.832	884.83
p,p'-DDD	1900	0.64	62.1799	211.14529	2.53283	1.7347316	90	16	82	1.75	1.665	3.2	99.23	102.095	102.09
p,p'-DDE	460	0.62	36.8025	66.324216	2.42728	1.5936549	88	13	85	1.60	1.665	3.01	48.58	67.4371	67.437
p,p'-DDT	780	0.54	56.929	111.82062	2.70677	1.6909835	88	20	77	1.70	1.665	3.14	76.78	110.504	110.5
Pentachlorophenol	22000	375	2419.28	3794.7343	7.05492	1.0920442	90	66	27	1.10	1.665	2.42	3085	2781.7	2781.7
Phenanthrene	360000	31	11193.7	41267.153	7.77697	1.6724867	90	1	99	1.65	1.665	3.07	18435	16651.6	16652
Phenol	17000	37	1245.99	2635.7526	6.12047	1.2493431	90	58	36	1.25	1.665	2.58	1709	1397.68	1397.7
Potassium	7980000	117000	1747133	1194743.8	14.1686	0.6719928	94	1	99	0.65	1.664	1.99	2E+06	2048851	2E+06
Pyrene	170000	20	8175.67	21517.183	7.79102	1.6225259	90	1	99	1.60	1.665	3.01	11951	15134.8	15135
Selenium	9700	255	2245.99	1840.766	7.36892	0.8972666	91	15	84	0.90	1.665	2.21	2567	2922.23	2922.2
Silver	37100	110	1882.07	4782.6861	6.30796	1.4460577	94	40	57	1.45	1.664	2.82	2703	2383.87	2383.9
Sodium	11900000	57600	1457464	1423093.3	13.9245	0.7747516	94	0	100	0.80	1.664	2.11	2E+06	1783953	2E+06
Styrene	385000	4.5	8489.74	44209.88	5.54303	2.7671367	90	86	4	2.75	1.665	4.59	16248	45122.4	45122
Tetrachloroethene	360000	3	7518.21	39793.45	5.52334	2.8298609	90	63	30	2.85	1.665	4.73	14501	56761.6	56762
Thallium	13700	240	2587.37	2882.7756	7.38929	0.9708415	93	14	85	0.95	1.664	2.26	3085	3258.1	3258.1
Toluene	3700000	2	71264.6	407745.43	6.32246	3.4480268	89	27	70	3.45	1.665	5.61	1E+05	1669512	2E+06
Toxaphene	2300	80	328.294	491.34204	5.19168	0.9284949	85	76	11	0.95	1.666	2.26	417.1	347.68	347.68
Trans-1,2-Dichloroethene	385000	2	8468.59	44213.631	5.44979	2.8085616	90	85	6	2.80	1.665	4.66	16227	48095.1	48095
Trans-1,3-Dichloropropene	385000	4.5	8484.79	44210.611	5.52552	2.7830762	90	89	1	2.80	1.665	4.66	16243	47706.6	47707
Trichloroethene	385000	1	13660	62290.349	5.53945	2.9260946	90	59	34	2.95	1.665	4.88	24590	83496.1	83496
Trichlorofluoromethane	385000	1	8484.74	44210.621	5.50658	2.8149909	90	88	2	2.80	1.665	4.66	16243	51998.8	51999
Vanadium	343000	11800	52691.5	64423.317	10.4905	0.7816688	94	0	100	0.80	1.664	2.11	6747	57942	57942
Vinyl chloride	385000	2	8477.01	44212.015	5.48747	2.8137394	90	86	4	2.80	1.665	4.66	16235	50804	50804
Xylenes	25000000	2	419816	2709426.6	7.45369	3.9429286	89	9	90	3.95	1.665	6.35	9E+05	5.9E+07	3E+07
Zinc	4350000	54400	681779	829308.2	12.888	1.0460711	92	0	100	1.05	1.664	2.36	8E+05	885607	885607

Table 2. UCL 95 and EPCs For Soil COPCs in U.S. Drum (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DefFreq	StdDev	Stal	hStal	UCL	InUCL	EPC
1,1,1-Trichloroethane	14500	5.5	730.7248	1798.094	4.7252	2.298826	109	97	11	2.30	1.6606	3.95	1016.7	3794.5	3794
1,1,2,2-Tetrachloroethane	15000	5.5	876.289	2554.705	4.7237	2.287159	109	104	5	2.30	1.6606	3.95	1282.6	3672.1	3672
1,1,2-Trichloro-1,2,2-Trifluoroethane	16000	5.5	976.6422	2866.942	4.7364	2.340501	109	102	6	2.35	1.6606	4.02	1432.6	4361.6	4362
1,1,2-Trichloroethane	15000	5.5	876.0459	2554.788	4.7046	2.304032	109	107	2	2.30	1.6606	3.95	1282.4	3789.4	3789
1,1-Dichloroethane	15000	1	873.9266	2558.351	4.612	2.443407	109	92	16	2.45	1.6606	4.159	1280.8	5296.6	5297
1,1-Dichloroethane	15000	5.5	887.0963	2553.616	4.7364	2.305867	109	102	6	2.30	1.6606	3.95	1293.3	3910.1	3910
1,2,3,4,6,7,8-Heptachlorodibenzo-P-Dioxin	3.757	2.455	3.36475	0.615473	1.199	0.202615	4	0	100	0.20	2.353	2.747	4.0889	4.6682	3.757
1,2,3,4,6,7,8-Heptachlorodibenzo-P-Dioxin	3.003	1.186	1.6345	0.489667	0.457	0.303352	4	0	100	0.30	2.353	3.256	2.2106	2.9247	2.171
1,2,3,4,7,8-Hexachlorodibenzo-P-Dioxin	5.505	1.64	2.2615	0.677413	0.7817	0.303367	4	0	100	0.30	2.353	3.256	3.0505	4.0468	3.003
1,2,3,4,7,8-Hexachlorodibenzo-P-Dioxin	2.095	0.985	1.656375	0.508276	0.4624	0.351068	4	1	75	0.35	2.353	3.596	2.2544	3.5	2.095
1,2,3,6,7,8-Hexachlorodibenzo-P-Dioxin	5.531	0.7765	2.085625	2.306108	0.3621	0.922404	4	3	25	0.90	2.353	8.109	4.7988	165.01	5.531
1,2,3,7,8,9-Hexachlorodibenzo-P-Dioxin	2.059	0.9515	1.627875	0.499695	0.445	0.351245	4	1	75	0.35	2.353	3.596	2.2158	3.4411	2.059
1,2,3,7,8,9-Hexachlorodibenzo-P-Dioxin	2.038	1.1175	1.380375	0.441875	0.2892	0.285682	4	2	50	0.30	2.353	3.256	1.9002	2.3798	2.038
1,2,4-Trichlorobenzene	15000	2	880.711	2556.394	4.668	2.364313	109	95	13	2.35	1.6606	4.02	1287.3	4347.8	4348
1,2-Dibromo-3-Chloropropane	15000	2	876.1514	2554.752	4.6964	2.325605	109	103	6	2.35	1.6606	4.02	1282.5	4024.3	4024
1,2-Dibromoethane	15000	5.5	876.289	2554.705	4.7237	2.287159	109	104	5	2.30	1.6606	3.95	1282.6	3672.1	3672
1,2-Dichlorobenzene	16000	1	885.2752	2564.522	4.8089	2.225292	109	80	27	2.25	1.6606	3.881	1293.2	3347.1	3347
1,2-Dichloroethane	14500	2	974.7523	2530.86	4.7582	2.393948	109	95	13	2.40	1.6606	4.089	1377.3	5248.3	5248
1,2-Dichloroethane	15000	5.5	876.078	2554.777	4.7085	2.301497	109	106	3	2.30	1.6606	3.95	1282.4	3758.4	3758
1,3-Dichloropropane	120000	1	2098.904	11722.31	4.7843	2.451737	109	98	10	2.45	1.6606	4.159	3963.4	6444.1	6444
1,4-Dichlorobenzene	130000	2	2424.936	12684.68	5.1253	2.488252	109	58	47	2.45	1.6606	4.159	4442.5	9500.6	9501
2,2'-Oxybis(1-Chloro)Propane	48000	190	4495.648	7493.723	7.3083	1.528418	108	89	18	1.55	1.6608	2.945	5693.2	7416.4	7416
2,3,4,6,7,8-Hexachlorodibenzo-P-Dioxin	5.539	0.7775	2.29075	2.192506	0.5368	0.839555	4	2	50	0.85	2.353	7.678	4.8702	100.55	5.539
2,3,4,7,8-Pentachlorodibenzo-P-Dioxin	1.998	1.098	1.3535	0.433059	0.2696	0.285556	4	2	50	0.30	2.353	3.256	1.863	2.3329	1.998
2,3,7,8-Tetrachlorodibenzo-P-Dioxin	2.14	0.469	1.47475	0.77091	0.2369	0.701615	4	1	75	0.70	2.353	6.391	2.3817	21.584	2.14
2,4,5-Trichlorophenol	120000	470	11085.42	18731.41	8.1513	1.574716	108	101	6	1.60	1.6608	3.009	14079	18943	18943
2,4,6-Trichlorophenol	48000	190	4427.5	7515.937	7.2441	1.560119	108	99	8	1.55	1.6608	2.945	5628.6	7370.5	7371
2,4-Dichlorophenol	48000	76	4421.907	7519.051	7.2206	1.588351	108	99	8	1.60	1.6608	3.009	5623.5	7661.5	7661
2,4-Dimethylphenol	48000	22	3968.074	6599.958	7.0023	1.748154	108	75	31	1.75	1.6608	3.2	5022.8	8700.6	8701
2,4-Dinitrophenol	210000	470	17741.11	30114.24	8.5813	1.617603	108	34	69	1.60	1.6608	3.009	22554	31574	31574
2,4-Dinitrotoluene	48000	190	4423.75	7518.013	7.2313	1.573189	108	101	6	1.55	1.6608	2.945	5625.2	7454.7	7455
2,6-Dinitrotoluene	48000	190	4419.861	7520.039	7.2237	1.578146	108	100	7	1.60	1.6608	3.009	5621.7	7539.9	7540
2-Chloronaphthalene	48000	37	4421.685	7519.197	7.2132	1.603436	108	100	7	1.60	1.6608	3.009	5623.3	7825.1	7825
2-Chlorophenol	48000	190	4441.343	7514.274	7.2377	1.575912	108	100	7	1.60	1.6608	3.009	5642.2	7614.5	7614
2-Hexanone	18000	5.5	878	2542.968	4.753	2.278131	110	104	5	2.30	1.6604	3.95	1280.6	3677	3677
2-Methylnaphthalene	76000	26	4267.472	10491.59	6.7591	1.826536	108	11	90	1.85	1.6608	3.333	5944.2	8231.7	8232
2-Methylphenol	48000	21	4330.657	7546.821	7.0507	1.689254	108	89	18	1.70	1.6608	3.136	5536.7	8347	8347
2-Nitroaniline	120000	470	11085.42	18731.41	8.1513	1.574716	108	101	6	1.60	1.6608	3.009	14079	18943	18943
2-Nitrophenol	48000	190	4423.75	7518.013	7.2313	1.573189	108	101	6	1.55	1.6608	2.945	5625.2	7454.7	7455
3,3'-Dichlorobenzidine	48000	190	4423.75	7518.013	7.2313	1.573189	108	101	6	1.55	1.6608	2.945	5625.2	7454.7	7455
3-Nitroaniline	120000	470	11085.42	18731.41	8.1513	1.574716	108	101	6	1.60	1.6608	3.009	14079	18943	18943

Table 2. UCL 95 and EPCs For Soil COPCs In U.S. Drum (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DefFreq	StdDev	Std	hStd	UCL	InUCL	EPC	
4,6-Dinitro-2-methylphenol	120000	180	11244.86	18877.15	8.1428	1.602874	108	99	8	1.60	1.6608	3.009	14262	19802	19802	
4-Bromophenyl phenyl ether	48000	190	4488.565	7570.422	7.2377	1.581263	108	100	7	1.60	1.6608	3.009	5698.4	7691	7691	
4-Chloro-3-methylphenol	48000	61	4348.759	7507.945	7.1975	1.586844	108	98	9	1.60	1.6608	3.009	5548.6	7465.6	7466	
4-Chloroaniline	48000	28	4419.019	7539.464	7.129	1.691988	108	92	15	1.70	1.6608	3.136	5623.9	8720.6	8721	
4-Chlorophenyl phenyl ether	48000	190	4400.138	7487.186	7.234	1.566138	108	102	6	1.55	1.6606	2.945	5591	7362.4	7362	
4-Methylphenol	48000	20	4496.833	8302.411	6.9712	1.846778	108	54	50	1.85	1.6608	3.333	5823.7	10632	10632	
4-Nitroaniline	120000	470	11085.42	18731.41	8.1513	1.574716	108	101	6	1.60	1.6608	3.009	14079	18943	18943	
4-Nitrophenol	120000	470	13057.64	21247.57	8.2091	1.65457	108	92	15	1.65	1.6608	3.072	16453	23607	23607	
Acenaphthene	48000	43	3717.815	7525.487	6.8365	1.703576	108	31	71	1.70	1.6608	3.136	4920.5	6661.7	6662	
Acenaphthylene	48000	20	4240.481	7612.295	6.7607	1.982187	108	62	43	2.00	1.6608	3.533	5457	12116	12116	
Acetone	31000	5.5	1982.991	5390.989	5.8837	1.932006	109	109	13	88	1.95	1.6606	3.466	2840.5	4422.6	4423
Acetophenone	48000	32	4346.019	7536.331	7.1069	1.698723	108	93	14	1.70	1.6608	3.136	4920.5	6661.7	6662	
Aldrin	200	0.95	6.487019	24.0247	0.8821	1.054307	104	93	14	1.70	1.6608	3.136	5550.4	8645.5	8646	
alpha-BHC	400	0.95	7.031429	38.99586	0.7467	0.966617	105	74	30	1.05	1.6617	2.361	10.402	4.407	4.407	
alpha-Chlordane	200	0.6	7.77028	22.77186	0.9623	1.155201	107	45	58	1.15	1.661	2.47	11.427	6.7312	6.731	
alpha-Endosulfon	7400	0.84	84.22537	713.745	1.1954	1.608963	108	65	40	1.60	1.6608	3.009	198.29	19.254	19.25	
Aluminum	2.3E+07	1060000	8793670	3769275	15.882	0.505713	109	0	100	0.50	1.6606	1.876	9E+06	1E+07	1E+07	
Anthrone	68000	22	4245.324	8799.777	6.9898	1.79209	108	26	76	1.80	1.6608	3.267	5651.6	9523.4	9523	
Anilmony	218000	1100	12518.18	35054.42	8.2105	1.23042	55	0	100	1.25	1.6749	2.58	20435	12082	12082	
Arochlor 1016	3950	19	91.15238	388.2896	3.5659	0.909984	105	95	10	0.90	1.6615	2.206	154.11	65.154	65.15	
Arochlor 1221	8000	38	185.0429	786.5451	4.2745	0.910714	105	95	10	0.90	1.6615	2.206	154.11	65.154	65.15	
Arochlor 1232	3950	19	91.15238	388.2896	3.5659	0.909984	105	95	10	0.90	1.6615	2.206	154.11	65.154	65.15	
Arochlor 1242	45000	19	3125.28	6607.676	6.1293	2.307287	109	29	73	2.30	1.6606	3.95	4176.3	15805	15805	
Arochlor 1248	3950	19	166.2333	559.5608	3.7653	1.199022	105	91	13	1.20	1.6615	2.525	256.96	119.23	119.2	
Arochlor 1254	64000	19	1908.171	6485.509	5.7042	2.075019	108	31	71	2.10	1.6608	3.672	2944.6	5397.5	5398	
Arochlor 1260	64000	19	1431.307	8149.737	4.462	1.794306	106	65	39	1.80	1.6613	3.267	2746.3	768	768	
Arsenic	82500	840	14394.86	14122.15	9.2574	0.799268	109	0	100	0.80	1.6606	2.112	16641	16971	16971	
Atrazine	48000	190	4488.565	7570.422	7.2377	1.581263	108	100	7	1.60	1.6608	3.009	5698.4	7691	7691	
Barium	1740000	20500	284247.7	312374.1	12.087	0.978922	109	0	100	1.00	1.6606	2.306	333933	356099	4E+05	
Benzaldehyde	48000	22	4516.333	7634.496	7.1947	1.651539	108	91	16	1.65	1.6608	3.072	5736.4	8510.6	8511	
Benzene	20000	2	897.5963	2706.935	4.8309	2.104176	109	24	78	2.10	1.6606	3.672	1328.2	2411.8	2412	
Benzofluoranthene	100000	37	5626.444	12407.75	7.387	1.70308	108	21	81	1.70	1.6608	3.136	7609.4	11541	11541	
Benzofluoranthene	55000	25	5234.787	9798.884	7.2697	1.778284	108	22	80	1.80	1.6608	3.267	6800.8	12240	12240	
Benzofluoranthene	71000	20	5381.944	10632.37	7.2617	1.821134	108	21	81	1.80	1.6608	3.267	7081.1	13294	13294	
Benzofluoranthene	48000	37	4274.315	7540.581	7.0332	1.797582	108	21	81	1.80	1.6608	3.267	5479.4	10062	10062	
Benzofluoranthene	65000	30	5173.917	9768.716	7.2096	1.825215	108	27	75	1.85	1.6608	3.333	6735.1	12880	12880	
Benzyl Butyl Phthalate	63000	24	4590.778	9207.154	7.1158	1.716947	108	61	44	1.70	1.6608	3.136	6062.2	9047.8	9048	
Beryllium	2500	30	638.1651	470.3233	6.1583	0.860267	109	13	88	0.85	1.6606	2.159	712.97	818.17	818.2	
beta-BHC	400	0.95	8.251887	40.58897	0.7938	1.059487	106	70	34	1.05	1.6613	2.361	14.801	4.9487	4.949	
beta-Endosulfon	1500	1.3	21.8281	147.6765	1.3056	1.050499	105	84	20	1.05	1.6615	2.361	45.773	8.1706	8.171	
Biphenyl (Diphenyl)	48000	21	3698.481	6756.238	6.6907	1.891932	108	47	56	1.90	1.6606	3.4	4778.2	8975.5	8975	
Bis(2-Chloroethoxy) Methane	48000	190	4423.75	7518.013	7.2313	1.573189	108	101	6	1.55	1.6608	2.945	5625.2	7454.7	7455	

Table 2. UCL, 95 and EPCs For Soil COPCs in U.S. Drum (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	Defreq	StdDev	IStat	hStat	UCL	InUCL	EPC
Bis(2-Chloroethyl) Ether	48000	190	4423.75	7518.013	7.2313	1.573189	108	101	6	1.55	1.6608	2.945	5625.2	7454.7	7455
Bis(2-Ethylhexyl) Phthalate	480000	41	25377.25	66309.33	8.1731	2.142423	109	13	88	2.15	1.6606	3.742	35874	76068	76068
Bromodichloromethane	15000	4	876	2554.804	4.6971	2.315485	109	106	3	2.30	1.6606	3.95	1282.4	3858.2	3858
Bromoforn	30000	5.5	1170.22	3662.728	4.8	2.404687	109	92	16	2.40	1.6606	4.089	1752.8	5639.6	5639
Bromomethane	30000	5.5	1223.183	4246.486	4.9208	2.315313	109	73	33	2.30	1.6606	3.95	1898.6	4823	4823
Cadmium	161000	90	5324.45	16218.94	7.3379	1.568977	109	17	84	1.55	1.6606	2.945	7904.2	8211.6	8212
Cadmium	2.1E+08	2080000	611941.28	46579755	17.647	0.798315	109	0	100	0.80	1.6606	2.112	7E+07	7E+07	7E+07
Caprolactam	48000	33	4266.87	7509.485	7.1479	1.616513	108	91	16	1.60	1.6608	3.009	5467	7514.5	7515
Carbazole	48000	23	3805.37	7425.866	6.7222	1.828845	108	39	64	1.85	1.6608	3.333	4992.1	7973.6	7974
Carbon disulfide	30000	2	1051.495	3539.53	4.9767	2.163225	109	68	38	2.15	1.6606	3.742	1614.5	3279.1	3279
Carbon tetrachloride	16000	5.5	976.6422	2866.942	4.7364	2.340501	109	102	6	2.35	1.6606	4.02	1432.6	4361.6	4362
Chlorobenzene	120000	2	2395.702	11941.09	5.0611	2.428013	109	61	44	2.45	1.6606	4.159	4293	7945.4	7945
Chloroethane	30000	5	1338.376	4395.59	4.8746	2.421207	109	79	28	2.40	1.6606	4.089	2037.5	6363.8	6364
Chloroform	15000	5.5	796.3486	2232.878	4.6751	2.286645	109	102	6	2.30	1.6606	3.95	1151.5	3493.2	3493
Chloromethane	29000	5.5	1036.06	3477.049	4.7576	2.358393	109	97	11	2.35	1.6606	4.02	1589.1	4678.7	4679
Chromium	1070000	3300	116278.9	182597	10.916	1.182847	109	0	100	1.20	1.6606	2.525	145322	147754	1E+05
Chrysene	100000	27	5503.102	12143.28	7.3567	1.739773	108	15	86	1.75	1.6608	3.2	7443.7	12190	12190
cis-1,2-Dichloroethene	15000	1	918.055	2589.043	4.5874	2.477045	109	79	28	2.50	1.6606	4.228	1329.9	5785	5785
cis-1,3-Dichloropropene	15000	5.5	876.0459	2654.788	4.7046	2.306032	109	107	2	2.30	1.6606	3.95	1282.4	3789.4	3789
Cobalt	52500	550	9642.661	6723.944	8.969	0.694693	109	2	98	0.70	1.6606	2.025	10712	11449	11449
Copper	6010000	10700	258911.9	650642.6	11.496	1.280329	109	0	100	1.30	1.6606	2.64	362401	308935	3E+05
Cyanide	14700	70	918.9216	2111.306	5.714	1.260589	102	31	70	1.25	1.6621	2.58	1266.4	927.18	927.2
Cyclohexane	15000	2	910.5046	2595.658	4.7322	2.301777	109	62	43	2.30	1.6606	3.95	1323.4	3851.1	3851
delta-BHC	200	0.58	4.946509	19.65667	0.665	0.953466	106	78	26	0.96	1.6613	2.266	8.1182	3.779	3.779
Di-N-Butyl Phthalate	48000	24	3873.556	6746.679	6.8269	1.8675	108	54	50	1.85	1.6608	3.333	4951.8	9628.2	9628
Di-N-Octylphthalate	50000	74	4802.796	8781.319	7.2391	1.611017	108	81	25	1.60	1.6608	3.009	6206.2	8146.5	8146
Dibenz(a,h)Anthracene	48000	20	3888.639	7392.38	6.7289	1.896069	108	40	63	1.90	1.6608	3.4	5070	9411.2	9411
Dibenzofuran	48000	21	3879.778	7380.215	6.7259	1.915476	108	36	67	1.90	1.6608	3.4	5059.2	9798.8	9799
Dibromochloromethane	30000	5.5	1054.991	3556.857	4.7364	2.346335	109	102	6	2.35	1.6606	4.02	1620.7	4431.7	4432
Dichlorodifluoromethane	15000	2	875.9817	2554.81	4.6908	2.325592	109	106	3	2.35	1.6606	4.02	1282.3	4001.6	4002
Dieldrin	395	1.9	10.36934	39.04617	1.3962	0.990541	106	91	14	1.00	1.6613	2.306	16.67	8.2461	8.246
Diethyl Phthalate	48000	21	4048.009	7271.366	7.0321	1.688544	108	82	24	1.70	1.6608	3.136	5210.1	7860.7	7861
Dimethyl Phthalate	48000	20	4406.231	7527.031	7.1694	1.653167	108	97	10	1.65	1.6608	3.072	5609.1	8323.7	8324
Endosulfan sulfate	395	1.9	9.090554	38.49238	1.2776	0.907664	107	96	10	0.90	1.661	2.206	15.267	6.5798	6.58
Endrin	395	1.9	9.237864	39.19742	1.2688	0.916931	103	94	9	0.90	1.6619	2.206	15.657	6.6158	6.616
Endrin aldehyde	395	1.9	10.70048	40.47026	1.3176	1.000947	105	92	12	1.00	1.6615	2.306	17.262	7.7285	7.728
Endrin ketone	395	1.1	14.43585	44.61628	1.5984	1.154907	106	53	50	1.16	1.6613	2.47	21.635	12.728	12.73
Ethylbenzene	260000	1	8914.454	35533.19	5.4836	3.0716	109	20	82	3.05	1.6606	5.02	14248	118753	1E+05
Fluoranthene	340000	21	10112.68	34807.38	7.9021	1.666916	109	11	90	1.65	1.6606	3.072	15649	17752	17752
Fluorene	48000	22	3826.514	7268.363	6.9645	1.741717	109	27	75	1.75	1.6606	3.2	4982.6	8164.8	8165
gamma-BHC	200	0.95	4.822115	19.86272	0.6111	0.927839	104	93	11	0.95	1.6617	2.256	8.0586	3.4826	3.483
gamma-Chlorodane	200	0.95	8.44619	24.4258	0.9107	1.221819	105	79	25	1.20	1.6615	2.525	12.407	7.0966	7.097

Table 2. UCL 95 and EPCs For Soil COPCs in U.S. Drum (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDel	Defreq	StdDev	tStat	hStat	UCL	lnUCL	EPC
Heptachlor	640	0.67	36.39339	84.53663	1.9784	1.835364	109	37	66	1.85	1.6606	3.333	49.84	66.774	66.77
Heptachlor epoxide	200	0.75	6.096667	20.67361	0.7871	1.069312	105	83	21	1.05	1.6615	2.361	9.4487	4.9844	4.984
Hexachlorobenzene	48000	69	4485.546	7572.135	7.2215	1.603008	108	99	8	1.60	1.6608	3.009	5695.7	7884.1	7884
Hexachlorobutadiene	85000	28	4393.083	7476.529	7.2444	1.595908	108	91	16	1.60	1.6608	3.009	5587.9	7801.6	7802
Hexachlorocyclopentadiene	48000	205	7731.378	12662.77	7.8449	1.562868	98	4	96	1.55	1.663	2.945	9791.4	13814	13814
Hexachloroethane	48000	190	4423.75	7518.013	7.2313	1.573189	108	101	6	1.55	1.6608	2.945	5625.2	7454.7	7455
Indeno(1,2,3-CD)pyrene	48000	28	4490.815	7672.909	7.0516	1.860214	108	31	71	1.85	1.6608	3.333	5717	11864	11864
Iron	2.6E+08	3700000	58171193	54597986	17.511	0.873347	109	0	100	0.85	1.6606	2.159	7E+07	7E+07	7E+07
Isophorane	48000	22	4351.602	7520.401	7.1468	1.656493	108	92	15	1.65	1.6608	3.072	5553.5	8191	8191
Isopropylbenzene	15000	1	1088.647	2461.064	5.0635	2.326423	109	34	69	2.35	1.6606	4.02	1480.1	5822.3	5822
Lead	5090000	10300	552611	839481.6	12.295	1.50751	109	0	100	1.50	1.6606	2.881	686136	1E+06	1E+06
Magnesium	6.4E+07	1170000	14029358	10022227	16.14	0.882509	109	0	100	0.90	1.6606	2.206	2E+07	2E+07	2E+07
Manganese	3.1E+07	110000	2287670	5499833	13.636	1.144567	109	0	100	1.15	1.6606	2.47	3E+06	2E+06	2E+06
Mercury	6000	25	506.422	843.5483	5.4454	1.27224	109	17	84	1.25	1.6606	2.58	640.59	713.8	713.8
Methoxychlor	7300	7.9	101.5562	711.371	3.0324	0.984501	105	73	30	1.00	1.6615	2.306	216.9	42.081	42.08
Methyl acetate	31000	3	1263.606	3957.613	4.8774	2.33024	109	47	57	2.35	1.6606	4.02	1893.1	4883.8	4884
Methyl ethyl ketone	30000	5	1057.518	3543.368	5.0568	2.047561	109	50	54	2.05	1.6606	3.603	1621.1	2598.9	2599
Methyl isobutyl ketone	15000	1	879.867	2554.82	4.6276	2.45242	109	85	22	2.45	1.6604	4.159	1286.2	5519.7	5520
Methylcyclohexane	15000	1	911.8636	2560.235	4.7045	2.308438	110	36	67	2.30	1.6604	3.95	1317.2	3798.2	3798
Methylcyclohexane	15000	1	873.8991	2450.938	4.6753	2.337395	109	66	39	2.35	1.6606	4.02	1263.7	4068.5	4069
Methylcyclohexane	15000	1	873.8991	2450.938	4.6753	2.337395	109	66	39	2.35	1.6606	4.02	1263.7	4068.5	4069
Methylcyclohexane	15000	1	873.8991	2450.938	4.6753	2.337395	109	66	39	2.35	1.6606	4.02	1263.7	4068.5	4069
N-Nitrosodi-N-Propylamine	48000	190	4450.602	7510.609	7.2441	1.575967	108	99	8	1.60	1.6608	3.136	5189.8	7857.7	7858
N-Nitrosodiphenylamine	48000	24	4038.287	7205.214	6.9881	1.710335	108	72	33	1.70	1.6608	3.136	5189.8	7857.7	7858
Naphthalene	110000	27	7521.761	17568.94	7.1114	2.009678	109	8	93	2.00	1.6606	3.533	10316	18336	18336
Nickel	470000	2600	49107.34	60018.02	10.415	0.838661	109	0	100	0.85	1.6606	2.159	58654	56435	56435
Nitrobenzene	48000	190	4425.046	7518.059	7.2274	1.578656	108	100	7	1.60	1.6608	3.009	5626.5	7575.2	7575
Octachlorodibenzo-P-Dioxin	4.196	2.39	3.05525	0.823635	1.0915	0.255617	4	0	100	0.25	2.353	3.001	4.0243	4.7923	4.196
Octachlorodibenzofuran	9.845	2.756	4.954	3.336962	1.4566	0.589258	4	0	100	0.60	2.353	5.547	8.8799	33.696	9.845
p,p'-DDD	3700	1.3	122.2028	392.0719	3.2335	1.78384	109	18	83	1.80	1.6606	3.267	184.56	218.16	218.2
p,p'-DDE	730	1.1	61.52339	95.83597	2.9149	1.797286	109	35	68	1.80	1.6606	3.267	76.767	163.2	163.2
p,p'-DDT	395	1.5	14.05524	41.6042	1.672	1.173508	105	82	22	1.15	1.6615	2.47	20.801	12.741	12.74
Pentachlorophenol	120000	310	16470.84	25380.21	8.4336	1.700087	107	57	47	1.70	1.661	3.136	20546	32748	32748
Phenanthrene	170000	40	7902.945	17864.05	7.8333	1.665623	109	8	93	1.65	1.6606	3.072	10744	16529	16529
Phenol	48000	30	4363.343	7503.011	7.1307	1.679365	108	80	26	1.70	1.6608	3.136	5562.4	8518.1	8518
Potassium	4410000	240000	11601165	898629.8	14.11	0.634286	109	0	100	0.65	1.6606	1.986	2E+06	2E+06	2E+06
Pyrene	160000	30	7108.752	18006.52	7.6808	1.678751	109	7	94	1.70	1.6606	3.136	9972.8	14714	14714
Selenium	11200	150	2277.294	1830.751	7.3965	0.899124	109	9	92	0.90	1.6606	2.206	2568.5	2956.1	2956
Silver	24200	135	3455.183	4267.507	7.4944	1.199629	109	21	81	1.20	1.6606	2.525	4134	4941.8	4942
Sodium	8530000	43150	1151001	1340175	13.563	0.857654	109	1	99	0.85	1.6606	2.159	1E+06	1E+06	1E+06
Styrene	15000	6.5	915.1881	2578.867	4.7629	2.299948	109	102	6	2.30	1.6606	3.95	1325.4	3952	3952
Tert-Butyl Methyl Ether	30000	5.5	1115.128	3572.252	4.8127	2.397853	109	90	17	2.40	1.6606	4.069	1683.3	5602.7	5603
Tetrachloroethene	28000	1	1094.005	3558.935	4.6351	2.448188	109	63	42	2.45	1.6606	4.159	1676	5494.9	5495
Thallium	3000	230	901.05	580.0476	6.6097	0.62761	100	49	51	0.65	1.6626	1.986	997.49	1024.4	1024

Table 2. UCL, 95 and EPCs For Soil COPCs in U.S. Drum (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DefFreq	StdDev	hStat	UCL	InUCL	EPC
Toluene	730000	2	11654.45	74502.54	5.3254	2.616781	109	14	87	2.60	1.6606	4.372	23505	18958
Toxaphene	20000	95	465.9524	1966.794	5.206	0.908405	105	95	10	0.90	1.6615	2.206	784.85	335.05
Trans-1,2-Dichloroethene	15000	1	895.5183	2560.827	4.6456	2.420451	109	97	11	2.40	1.6606	4.089	1302.8	5050.4
Trans-1,3-Dichloropropene	15000	5.5	876.0459	2554.788	4.7046	2.306032	109	107	2	2.30	1.6606	3.95	1282.4	3789.4
Trichloroethene	15000	1	807.7661	2229.338	4.6288	2.345331	109	74	32	2.35	1.6606	4.02	1162.4	3968.9
Trichlorofluoromethane	30000	2	1413.055	4393.498	4.9013	2.544836	109	66	39	2.55	1.6606	4.3	2111.9	9821.2
Vanadium	283000	1600	31255.96	43354	9.9366	0.830116	109	0	100	0.85	1.6606	2.159	38152	34670
Vinyl chloride	30000	5.5	1053.5	3541.18	4.7697	2.347269	109	96	12	2.35	1.6606	4.02	1616.7	4593.5
Xylenes	950000	2	39499.22	140287.9	6.3638	3.393862	109	10	91	3.40	1.6606	5.534	6181.3	1E+06
Zinc	9250000	23600	871733.9	1457734	12.804	1.38248	109	0	100	1.40	1.6606	2.761	1E+06	1E+06

Table 3. UCL 95 and EPCs For Soil COPCs In Unnamed Parcel (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DefFreq	StdDev	ISat	UCL	InUCL	EPC
1,2,3,4,7,8-Hexachlorodibenzo-P-Dioxin	1.398	0.27	0.685	0.4922046	-0.556	0.677574	4	1	75	0.70	2.353	6.391	1.2641	8.7893
1,2,3,4,7,8-Hexachlorodibenzofuran	3.178	0.291	1.81425	1.2406808	0.2845	1.064582	4	0	100	1.05	2.353	9.4151	3.2739	763.62
1,2,3,6,7,8-Hexachlorodibenzo-P-Dioxin	1.338	0.484	0.71975	0.4128263	-0.428	0.481364	4	0	100	0.50	2.353	4.721	1.2054	2.719
1,2,3,6,7,8-Hexachlorodibenzofuran	3.193	0.146	1.4905	1.2653449	-0.058	1.316321	4	2	50	1.30	2.353	11.604	2.9792	15181
1,2,3,7,8,9-Hexachlorodibenzo-P-Dioxin	1.315	0.476	0.70775	0.4054827	-0.444	0.480875	4	0	100	0.50	2.353	4.721	1.1848	1.315
1,2,3,7,8,9-Hexachlorodibenzofuran	4.083	0.187	1.67588	1.6939224	0.0154	1.286819	4	3	25	1.30	2.353	11.604	3.6688	12897
1,2,3,7,8-Pentachlorodibenzo-P-Dioxin	1.0425	0.413	0.72388	0.2597609	-0.376	0.385185	4	3	25	0.40	2.353	3.9355	1.0295	1.7744
1,2,3,7,8-Pentachlorodibenzofuran	0.463	0.277	0.34	0.086326	-1.101	0.23744	4	3	25	0.25	2.353	3.001	0.4416	0.5162
1,2,4-Trichlorobenzene	2000000	1	64308	331757.41	3.2857	2.564741	81	14	83	2.55	1.667	4.2999	125745	2459.3
1,2-Dibromo-3-Chloropropane	1000000	5	27510	146718.61	3.1977	2.438309	81	51	37	2.45	1.667	4.1585	54680	1486.2
1,2-Dibromodichloroethane	1000000	5	32193.4	165871.13	3.0777	2.465325	81	64	21	2.45	1.667	4.1585	62910	1426.3
1,2-Dichlorobenzene	2000000	2	64282.9	331762.22	3.1159	2.632227	81	6	93	2.65	1.667	4.4437	125720	2665
Arochlor 1254	41000	19.5	925.926	4559.7681	5.2225	1.510458	81	35	57	1.50	1.667	2.881	1770.3	943.62
Arochlor 1260	2800	19.5	270.079	430.05175	4.9687	1.128843	82	34	59	1.15	1.666	2.4704	349.22	370.81
Arsenic	99900	1100	18854.2	13732.224	9.6163	0.737515	83	0	100	0.75	1.666	2.0685	21366	23313
Barium	10800000	4000	715273	1649867.9	12.603	1.224828	83	0	100	1.25	1.666	2.58	1E+06	892895
Benzaldehyde	7500	52	919.607	1474.3744	6.113	1.057917	84	76	100	1.05	1.666	2.3608	1187.6	1039.7
Benzene	2000000	1	63564.9	329771.74	3.2975	2.761949	82	1	99	2.75	1.666	4.5875	124252	5011.4
Benzo(a)anthracene	310000	81	6079.06	33915.926	6.7561	1.530133	84	9	89	1.55	1.666	2.9448	12244	4543.2
Benzo(a)pyrene	250000	74	5238.27	27410.015	6.7413	1.50594	84	10	88	1.50	1.666	2.881	10221	4236.2
Benzo(b)fluoranthene	350000	44	7158.49	38493.61	6.9122	1.570759	84	8	90	1.55	1.666	2.9448	14156	5730.7
Benzo(g,h,i)perylene	55000	66	1980.61	6290.8802	6.3281	1.407916	84	13	85	1.40	1.666	2.7606	3124.1	2311.9
Benzo(k)fluoranthene	150000	54	3953.37	16943.932	6.6957	1.487562	84	14	83	1.50	1.666	2.881	7033.4	3914.9
Benzyl Butyl Phthalate	43000	48	1782.17	5165.8393	6.2162	1.383023	84	46	45	1.40	1.666	2.7606	2721.2	1981.6
Beryllium	3000	140	1013.98	564.48863	6.7406	0.660045	83	8	90	0.65	1.666	1.9855	1117.2	1215.8
beta BHC	370	0.81	32.2279	50.346638	2.6613	1.367315	81	17	79	1.35	1.667	2.7004	41.551	55.084
Biphenyl (Diphenyl)	7500	50	805.083	1403.7012	5.9402	1.12017	84	59	30	1.10	1.666	2.4156	1060.2	947.01
Bis(2-Chloroethyl) Ether	14000	200	1553.04	2652.8789	6.4823	1.178338	84	46	45	1.20	1.666	2.5252	2035.3	1813.8
1,1,1-Trichloroethane	52000000	1	773903	5806820.1	2.9179	2.954548	84	35	58	2.95	1.666	4.8751	2E+06	7069.8
1,1,2,2-Tetrachloroethane	1000000	5	24542.8	139938.3	3.0883	2.417397	81	62	23	2.40	1.667	4.089	50457	1230.7
1,1,2-Trichloro-1,2,2-Trifluoroethane	1000000	5	31417.5	163911.13	3.0379	2.439326	83	66	20	2.45	1.666	4.1585	61396	1253
1,1,2-Trichloroethane	1000000	5	31417.1	163911.21	2.9973	2.451276	83	71	14	2.45	1.666	4.1585	61395	1245.7
1,1-Dichloroethane	1000000	5	26477.4	143897.02	2.9966	2.415057	83	69	17	2.40	1.666	4.089	52795	1100.4
1,1-Dichloroethane	1000000	5	31417	163911.22	2.9878	2.455152	83	72	13	2.45	1.666	4.1585	61395	1247.9
1,1,2,3,4,6,7,8-Heptachlorodibenzo-P-Dioxin	1.902	0.901	1.3355	0.4255541	0.252	0.314019	4	0	100	0.30	2.353	3.2555	1.8362	2.4389
1,2,3,4,6,7,8-Heptachlorodibenzofuran	3.684	0.376	1.552	1.4618374	0.1144	0.937349	4	0	100	0.95	2.353	8.5433	3.2719	177.17
1,2,3,4,6,7,8-Heptachlorodibenzo-P-Dioxin	2.5485	0.52	1.51013	0.8383329	0.2657	0.670256	4	1	75	0.65	2.353	5.969	2.4964	16.447
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1000000	3	24074.1	137184.45	2.9856	2.431565	83	67	19	2.45	1.666	4.1585	49164	1162.7
1,2-Dichloroethane	1000000	5	31417.2	163911.19	3.0057	2.44883	83	70	16	2.45	1.666	4.1585	61395	1247.2
1,2-Dichloropropane	1000000	2	65990.9	335811.31	3.3386	2.64366	79	13	84	2.65	1.667	4.4437	128977	3509.5
1,3-Dichlorobenzene	2000000	1	48062.1	288572.01	3.3568	2.686496	82	5	94	2.70	1.666	4.5156	101168	4078

Table 3. UCL 95 and EPCs For Soil COPCs in Unnamed Parcel (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DefFreq	StdDev	StDev	hStat	UCL	InUCL	EPC
2,2'-Oxybis(1-Chloropropane)	14000	170	1605.67	2628.5963	6.6258	1.093824	84	27	68	1.10	1.666	2.4156	2084.5	1833.6	1833.6
2,3,4,6,7,8-Hexachlorodibenzofuran	3.197	0.1465	1.4925	1.2668137	-0.056	1.315312	4	2	50	1.30	2.353	11.604	2.9829	15087	3.197
2,3,4,7,8-Pentachlorodibenzofuran	0.908	0.272	0.5165	0.2880654	-0.773	0.542221	4	1	75	0.55	2.353	6.134	0.8554	2.6671	0.908
2,3,7,8-Tetrachlorodibenzofuran	1.677	0.271	0.817	0.6051352	-0.408	0.750233	4	0	100	0.75	2.353	6.8185	1.5289	16.888	1.677
2,4-Dimethylphenol	7500	150	976.488	1520.1842	6.1757	1.048135	84	81	4	1.05	1.666	2.3608	1252.8	1093	1093
2,4-Dinitrophenol	38000	490	3589.52	6307.4679	7.4544	1.066735	84	40	52	1.05	1.666	2.3608	4736.1	4023.1	4023.1
2-Chloronaphthalene	120000	99	2277.61	13063.072	6.1821	1.163377	84	81	4	1.15	1.666	2.4704	4652.2	1305.4	1305.4
2-Hexanone	200000	55	4740.3	277859.7	3.2279	2.571188	84	47	42	2.55	1.667	4.2999	9891.6	2367.4	2367.4
2-Methylthiophene	44000	55	2812.19	6310.3599	6.5495	1.590975	84	16	81	1.60	1.666	3.0086	3959.3	4190	4190
2-Methylphenol	68000	150	1667.98	7442.0539	6.1918	1.122083	84	82	2	1.10	1.666	2.4156	3020.8	1235	1235
3,3'-Dichlorobenzidine	11000	195	1208.99	2098.3232	6.3008	1.08883	84	68	19	1.10	1.666	2.4156	1590.4	1352.3	1352.3
3-Nitroaniline	19000	490	2401.43	3675.7289	7.1326	1.080031	84	79	6	1.00	1.666	2.306	3069.6	2686	2686
4,6-Dinitro-2-methylphenol	38000	490	3032.38	5293.3121	7.3059	1.046674	84	58	31	1.05	1.666	2.3608	3994.6	3377.4	3377.4
4-Bromophenyl phenyl ether	11000	195	1136.55	2069.8747	6.2265	1.099616	84	77	8	1.10	1.666	2.4156	1511	1239.7	1239.7
4-Chloro-3-methylphenol	7500	195	940.298	1477.6195	6.1617	1.023891	84	83	1	1.00	1.666	2.306	1208.9	1038	1038
4-Chloroaniline	7500	195	968.274	1470.8352	6.21	1.009403	84	79	6	1.00	1.666	2.306	1225.6	1069.5	1069.5
4-Chlorophenyl phenyl ether	11000	195	1136.55	2069.8747	6.2265	1.099616	84	77	8	1.10	1.666	2.4156	1511	1239.7	1239.7
4-Methylphenol	25000	42	1153.57	2977.0404	5.9828	1.276679	84	49	42	1.30	1.666	2.6402	1694.7	1296.9	1296.9
4-Nitroaniline	36000	500	3157.62	5088.8955	7.4381	0.982465	84	42	50	1.00	1.666	2.306	4082.7	3531.3	3531.3
4-Nitrophenol	27000	490	2963.93	5196.0202	7.1986	1.099417	84	71	15	1.10	1.666	2.4156	3908.4	3276.3	3276.3
Acenaphthene	11000	55	1097.64	1878.7714	6.109	1.245236	84	32	62	1.25	1.666	2.58	1439.2	1389.8	1389.8
Acenaphthylene	11000	48	997.369	1822.5576	6.0315	1.216112	84	60	29	1.20	1.666	2.5252	1328.7	1221.7	1221.7
Acetone	200000	5	52049.5	285069.46	4.9583	2.269435	84	19	77	2.25	1.666	3.8805	103869	4915.1	4915.1
Acetophenone	7500	74	940.345	1477.8637	6.1533	1.040015	84	80	5	1.05	1.666	2.3608	1209	1057.4	1057.4
Aldrin	210	1	13.0125	27.60798	1.5751	1.325165	80	60	25	1.35	1.667	2.7004	18.173	17.387	17.387
alpha-BHC	17000	1	221.92	1899.671	1.5403	1.519708	80	49	39	1.50	1.667	2.881	575.95	24.231	24.231
alpha-Chlordane	115	1	14.1599	23.4967	1.8238	1.265103	81	39	52	1.25	1.667	2.58	18.511	19.865	19.865
alpha-Endosulfan	530	0.1	16.2935	66.25017	1.2174	1.478046	80	57	29	1.50	1.667	2.881	28.635	16.262	16.262
Aluminum	42500000	697000	9476386	7070022.4	15.839	0.721245	83	0	100	0.70	1.666	2.025	1E+07	1E+07	1E+07
Anthracene	75000	47	2365.08	8617.0583	6.2114	1.487931	84	24	71	1.50	1.666	2.881	3031.5	2413.6	2413.6
Anlimony	33400	830	10834.2	8280.4986	6.9329	0.954988	83	0	100	0.95	1.666	2.256	12349	15166	15166
Arochlor 1242	38000	19.5	1476.83	5085.7857	5.1722	1.931108	80	51	36	1.95	1.667	3.4664	2424.6	2416.1	2416.1
Arochlor 1248	6500	19.5	256.885	794.16306	4.3598	1.316051	78	76	3	1.30	1.667	2.6402	406.81	276.39	276.39
Bis(2-Ethylhexyl) Phthalate	95000	86	13510.5	20479.374	8.3506	1.750942	84	2	98	1.75	1.666	3.2	17233	36262	36262
Bromodichloromethane	1000000	5	31800.1	164882.63	3.0055	2.465097	82	71	13	2.45	1.666	4.1585	62143	1316.7	1316.7
Bromofarm	1000000	5	31417.1	163911.21	2.9923	2.451276	83	71	14	2.45	1.666	4.1585	61395	1245.7	1245.7
Bromomethane	1000000	5	31419.7	163910.72	3.1541	2.422652	83	51	39	2.40	1.666	4.089	61398	1316.5	1316.5
Cadmium	60800	110	5870.96	8735.6568	8.0383	1.259258	83	6	93	1.25	1.666	2.58	7468.6	9798.2	9798.2
Calcium	4.51E+08	7E+06	6.4E+07	73674150	17.598	0.812541	83	0	100	0.80	1.666	2.112	8E+07	7E+07	7E+07
Caprolactam	14000	69	1165.64	1956.9152	6.3948	1.036313	84	52	38	1.05	1.666	2.3608	1521.4	1339.9	1339.9
Carbazole	23000	58	1283.51	2991.2423	6.0591	1.31083	84	39	54	1.30	1.666	2.6402	1827.3	1477.5	1477.5

Table 3. UCL 95 and EPCs For Soil COPCs in Unnamed Parcel (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DelFreq	StdDev	ISat	hStat	UCL	InUCL	EPC
Carbon disulfide	1000000	1	31056.6	162954.26	3.0001	2.627113	84	24	71	2.65	1.666	4.4437	60678	2281	2281
Carbon tetrachloride	1000000	5.5	414717.2	163911.18	3.014	2.445189	83	69	17	2.45	1.666	4.1585	61395	1244.4	1244.4
Chlorobenzene	2000000	1	49247.8	291888.15	3.6688	2.68205	80	2	98	2.70	1.667	4.5156	103645	5586.5	5586.5
Chloroethane	1000000	6	31432.1	163908.38	3.3093	2.392552	83	35	58	2.40	1.666	4.089	61410	1410.7	1410.7
Chloroform	1000000	2	31416.9	163911.25	2.9653	2.467649	83	72	13	2.45	1.666	4.1585	61395	1265.4	1265.4
Chloromethane	1000000	3	31422.2	163910.22	3.2001	2.426185	83	46	45	2.45	1.666	4.1585	61400	1418.6	1418.6
Chromium	1620000	5900	151886	232148.63	11.297	1.123936	83	0	100	1.10	1.666	2.4156	194344	204520	204520
Chrysene	310000	71	6420.31	33955.709	6.9448	1.509124	84	8	90	1.50	1.666	2.881	12593	5222.6	5222.6
cis-1,2-Dichloroethene	1000000	1	31416.5	163911.33	2.9784	2.524851	83	63	24	2.55	1.666	4.2999	61395	1429	1429
cis-1,3-Dichloropropene	1000000	5	31417.1	163911.21	2.9973	2.451276	83	71	14	2.45	1.666	4.1585	61395	1245.7	1245.7
Cobalt	27200	600	11248.2	5360.3641	9.1886	0.611784	83	2	98	0.60	1.666	4.1585	61395	1245.7	1245.7
Copper	6540000	3900	432372	844294.73	12.286	1.131709	83	0	100	1.15	1.666	2.4704	586788	559779	559779
Cyclohexane	5400000	1	83446.8	599800.03	3.2161	2.702551	84	34	60	2.70	1.666	4.5156	192477	3668.5	3668.5
delta-BHC	115	0.46	8.92833	18.026594	1.2889	1.234747	78	75	4	1.25	1.667	2.58	12.332	11.181	11.181
Di-N-Butyl Phthalate	7500	66	947.69	1487.2792	6.0678	1.179812	84	48	43	1.20	1.666	2.5252	1218	1200.8	1200.8
Di-N-Octylphthalate	7500	46	1072.76	1808.4589	6.1456	1.150595	84	66	21	1.15	1.666	2.4704	1401.5	1235.8	1235.8
Dibenz(a,h)Anthracene	69000	33	1592	6512.3757	6.0221	1.337977	84	36	57	1.35	1.666	2.7004	2775.8	1500.9	1500.9
Dibenzofuran	7500	48	1055.04	1728.4817	6.0823	1.260974	84	37	56	1.25	1.666	2.58	1369.2	1386.3	1386.3
Dibromochloromethane	1000000	5	31417.1	163911.21	2.9973	2.451276	83	71	14	2.45	1.666	4.1585	61395	1245.7	1245.7
Dichlorodifluoromethane	1000000	5	31430.7	163908.65	3.2407	2.407255	83	42	49	2.40	1.666	4.089	61408	1373.6	1373.6
Dieldrin	175	1.95	22.5821	30.698492	2.488	1.15571	81	36	56	1.15	1.667	2.4704	28.267	32.299	32.299
Diethyl Phthalate	7500	68	923.881	1490.7769	6.0308	1.15781	84	66	21	1.15	1.666	2.4704	1194.9	1113.3	1113.3
Dimethyl Phthalate	7500	140	940.238	1477.7802	6.1585	1.028882	84	83	1	1.05	1.666	2.3608	1208.9	1047.8	1047.8
Endosulfan sulfate	940	0.28	34.0312	117.03737	2.1313	1.437608	81	59	27	1.45	1.667	2.8208	55.705	37.263	37.263
Endrin	225	1.95	18.1051	34.735772	2.024	1.231803	79	74	61	2.5	1.667	2.58	24.62	23.163	23.163
Endrin aldehyde	1100	1.1	31.0944	126.88891	2.0175	1.340177	80	64	20	1.35	1.667	2.7004	54.742	27.735	27.735
Endrin ketone	225	1.95	17.6367	34.292104	2.0033	1.223888	79	70	11	1.20	1.667	2.5252	24.069	22.246	22.246
Ethylbenzene	1800000	1	46056.3	248761.95	3.1347	2.703214	81	12	85	2.70	1.667	4.5156	92123	3474.3	3474.3
Fluoranthene	510000	57	12042.4	56942.212	7.3893	1.697125	84	5	94	1.70	1.666	3.1362	22393	12255	12255
Fluorene	18000	44	1482.12	2972.5822	6.2442	1.337118	84	27	68	1.35	1.666	2.7004	2022.5	1871.5	1871.5
gamma-BHC	115	0.22	8.549	16.694184	1.3168	1.22622	80	65	19	1.25	1.667	2.58	11.66	11.297	11.297
gamma-Chlordane	115	0.37	14.9133	23.4209	1.7259	1.442438	84	49	9	1.40	1.667	2.7606	103.03	17.157	17.157
Heptachlor	2800	1	44.0462	314.49906	1.4148	1.405798	79	72	13	1.20	1.667	2.5252	11.28	10.436	10.436
Heptachlor epoxide	90	1	8.39231	15.297316	1.2834	1.197645	78	68	81	1.10	1.666	2.4156	1511	1239.7	1239.7
Hexachlorobenzene	11000	195	1136.55	2059.8747	6.2265	1.099616	84	77	57	1.15	1.666	2.4704	2049.8	1820.4	1820.4
Hexachlorobutadiene	14000	200	1568.81	2645.9458	6.5236	1.157144	84	41	61	1.15	1.666	2.3608	1445.3	1166	1166
Hexachlorocyclopentadiene	14000	195	1082.5	1995.6719	6.21	1.071165	84	79	6	1.05	1.666	2.3608	1208.9	1052	1052
Hexachloroethane	7600	98	940.274	1477.8293	6.156	1.033951	84	83	1	1.05	1.666	2.7606	5812.2	2473.1	2473.1
Indeno(1,2,3-CD)pyrene	140000	57	3027.81	16317.846	6.3769	1.418759	84	15	82	1.40	1.666	2.7606	5812.2	2473.1	2473.1
Iron	4.3E+08	1E+06	9.5E+07	77809396	18.057	0.870047	83	0	100	0.85	1.666	2.159	1E+08	1E+08	1E+08
Isophorone	7500	65	939.583	1478.1911	6.1501	1.042847	84	83	1	1.05	1.666	2.3608	1208.3	1058	1058

Table 3. UCL 95 and EPCs For Soil COPCs In Unnamed Parcel (unit: ug/kg)

Analyte Name	Max Value	Min Value	Average	Standard Deviation	In Ave.	In Standard Deviation	Number	NonDet	DefFreq	ISldDev	ISlat	UCL	hUCL	EPC
Isopropylbenzene	200000	1	47384.4	291630.07	4.11	2.538581	80	4	95	2.55	1.667	4.2999	101715	5220.4
Lead	5710000	20400	880148	1019037.8	13.117	1.199868	83	0	100	1.20	1.666	2.5252	1E+06	1E+06
Magnesium	1.38E+08	751000	1E+07	15703791	15.755	0.856729	83	0	100	0.85	1.666	2.159	1E+07	1E+07
Manganese	13000000	112000	1270783	1740408.7	13.626	0.871177	83	0	100	0.85	1.666	2.159	2E+06	1E+06
Mercury	3800	25	634.458	558.61846	6.0952	0.925245	83	2	98	0.95	1.666	2.256	736.62	857.25
Methoxychlor	1150	0.54	71.119	163.71989	3.1593	1.485786	81	40	51	1.50	1.667	2.881	101.44	114.62
Methyl acetate	1100000	5	31413.8	165761.36	3.179	2.421664	83	47	43	2.40	1.666	4.089	61730	1345.8
Methyl ethyl ketone	200000	1	57312.7	303872.65	3.9912	2.523816	84	5	94	2.50	1.666	4.228	112550	4218.7
Methyl isobutyl ketone	480000	3	13018.9	68346.818	3.2026	2.4305	81	36	56	2.45	1.667	4.1585	25676	1460.1
Methylcyclohexane	13000000	2	194151	1462879.7	3.6468	2.557092	83	16	81	2.55	1.666	4.2999	461701	3396.1
Methylene chloride	1000000	5	28892	157284.5	3.061	2.398146	84	79	62	2.40	1.666	4.089	57483	1110.8
N-Nitrosodimethylamine	14000	195	1241.13	2243.0998	6.276	1.12556	84	71	15	1.15	1.666	2.4704	1648.9	1359.2
N-Nitrosodiphenylamine	7000	150	901.488	1340.5811	6.1812	0.983325	84	65	23	1.00	1.666	2.306	1145.2	1005.8
Naphthalene	330000	70	10067	41254.105	6.8874	1.813666	84	15	82	1.80	1.666	3.2666	17566	9724.7
Nickel	669000	4800	76598.8	94897.104	10.873	0.81362	83	0	100	0.80	1.666	2.112	93955	88764
Octachlorodibenzo-P-Dioxin	2.148	0.456	1.055	0.7551702	-0.119	0.659047	4	0	100	0.65	2.353	3.9355	1.95	3.5333
Octachlorodibenzofuran	1.816	0.791	1.3275	0.5272036	0.2211	0.419485	4	0	100	0.40	2.353	3.9355	1.95	3.5333
p,p'-DDD	1100	0.32	89.7101	164.20729	3.5244	1.599865	83	9	89	1.60	1.666	3.0086	119.74	207.63
p,p'-DDE	790	0.39	48.5721	88.816733	3.2408	1.245543	84	5	94	1.25	1.666	2.58	64.717	78.982
p,p'-DDT	570	1.95	25.4881	69.382141	2.1664	1.31251	80	63	21	1.30	1.667	2.4402	38.418	30.497
Pentachlorophenol	36000	110	3133.33	5210.2162	7.2998	1.117137	84	55	35	1.10	1.666	2.4156	4080.4	3714.7
Phenanthrene	210000	52	7831.21	25797.881	7.3149	1.683282	84	3	96	1.70	1.666	3.1362	12521	11059
Phenol	97000	61	2022.81	10573.837	6.1877	1.614761	84	78	7	1.15	1.666	2.4704	3944.9	1309.2
Potassium	3380000	162000	945361	637223.68	13.559	0.646161	83	0	100	0.65	1.666	1.9855	1E+06	1E+06
Pyrene	440000	50	10078.2	48688.998	7.3124	1.633955	84	4	95	1.65	1.666	3.0724	18929	9880.6
Selenium	20000	230	2818.13	2682.44	7.5906	0.912938	83	9	89	0.90	1.666	2.206	3308.7	3750.9
Silver	639000	110	10949.2	69932.081	7.486	1.468047	83	10	88	1.45	1.666	2.8208	23739	7958.1
Sodium	23600000	563000	1656277	2623052.3	14.044	0.574127	83	0	100	0.55	1.666	1.911	2E+06	2E+06
Styrene	200000	5	66846.6	337898.23	3.5392	2.579577	78	13	83	2.60	1.667	4.3718	130637	3468.4
Tert-Butyl Methyl Ether	1000000	5	31417	163911.22	2.9878	2.455152	83	72	13	2.45	1.666	4.1585	61395	1247.9
Tetrachloroethene	1000000	1	31800.2	164882.62	2.8827	2.568481	82	55	33	2.55	1.666	4.2999	62143	1649.8
Thallium	26000	355	6109.4	5228.6028	8.3613	0.910754	83	4	95	0.90	1.666	2.206	7065.7	8086.1
Toluene	8900000	2	248928	1355421.7	3.1294	2.905797	84	41	51	2.90	1.666	4.8032	495313	7210.3
trans-1,2-Dichloroethene	1000000	5	31416.9	163911.25	2.9768	2.458483	83	72	13	2.45	1.666	4.1585	61395	1246.2
trans-1,3-Dichloropropene	1000000	5	31044	162956.68	3.0269	2.43291	84	67	20	2.45	1.666	4.1585	60666	1208.3
Trichloroethene	460000	1	12982.7	69678.602	2.8176	2.398191	83	60	28	2.40	1.666	4.089	25726	876.69
Trichlorofluoromethane	1000000	1	30676.6	162019.21	2.5635	2.654188	85	34	60	2.65	1.666	4.4437	59950	1591.9
Vanadium	73400	1800	26734.9	13373.421	9.9656	0.608229	83	0	100	0.60	1.666	1.946	27181	29182
Vinyl chloride	1000000	1	31416.8	163911.27	2.9339	2.491264	83	67	19	2.50	1.666	4.228	61395	1339.8
Xylenes	560000	3	14996	79675.91	4.0799	2.911321	81	9	89	2.90	1.667	4.8032	297547	19560
Zinc	9990000	18700	1333453	1732384.7	13.468	1.195292	83	0	100	1.20	1.666	2.5252	2E+06	2E+06

APPENDIX B

Air Concentration Model of Groundwater COPCs

Air Concentration Model for Groundwater COPCs

Calculations of air concentrations are based on the assumption that during construction work, soil is excavated and groundwater is exposed to the air. The exposed area is modeled as a shallow pond with dimensions of 2 m x 2 m x 0.5 m. And EPC_{air} is calculated using a "box model" approach, described in U.S. EPA (1986), by using the following equation,

$$EPC_{air} = \frac{E}{W \times U \times H} \quad (1)$$

where:

H = Mixing height = 2 m (height of an average man)

U = Average wind speed within mixing zone = 4.6 m/s (U.S. Dept. of Commerce 2000)

W = Width dimension of the pond = 2 m

E = Emission rate (g/s)

The emission rate is determined by using the following equations (Thomas, 1990):

$$E = K_l \times C \times A \quad (2)$$

where:

K_l = Liquid phase mass transfer coefficient (cm/hour)

C = Concentration of chemical in liquid phase (mg/L)

A = Contaminated area (cm²) = 200 x 200 (cm²)

K_l is calculated from:

$$(K_v^c)_{env} = \frac{K_l}{Z} \quad (3)$$

where:

$(K_v^c)_{env}$ = Overall liquid phase exchange coefficient (hour⁻¹)

Z = Depth of the pond (cm) = 50 cm

$(K_v^c)_{env}$ for ponds is estimated by the equation:

$$(K_v^c)_{env} = \frac{D^c}{D^o} (K_v^o)_{Ponds} \quad (4)$$

where:

D^c = Diffusion coefficient of the chemical in water (cm^2/sec)

D^o = Diffusion coefficient of oxygen in water (cm^2/sec)

$= 2.20 \times 10^{-5} \text{ cm}^2/\text{sec}$ (Thomas, 1990 and EPA 1996)

$(K_v^o)_{\text{ponds}}$ = Oxygen reaeration coefficient (hour^{-1}) = 0.008

References:

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Table B-1.
AIR CONCENTRATION OF GROUNDWATER CONTAMINANTS

COPC	C _{liquid} (mg/L)	DI _W (cm ² /sec)	Do (cm ² /sec)	(Kv ⁰) _{ponds} (hr ⁻¹)	(Kv ⁰) _{ponds} (hr ⁻¹)	KL (cm/hour)	E (g/sec)	C _{air} (g/m ³)
Benzene	2.4	9.80E-06	2.20E-05	8.00E-03	3.56E-03	1.78E-01	4.75152E-06	1.72E-07
Methylene chloride	0.2	1.17E-05	2.20E-05	8.00E-03	4.25E-03	2.13E-01	4.01818E-07	1.46E-08
Chlorobenzene	0.2	8.70E-06	2.20E-05	8.00E-03	3.16E-03	1.58E-01	2.98788E-07	1.08E-08
Ethylbenzene	5.8	7.80E-06	2.20E-05	8.00E-03	2.84E-03	1.42E-01	9.13939E-06	3.31E-07
Methylene chloride	0.2	1.17E-05	2.20E-05	8.00E-03	4.25E-03	2.13E-01	4.01818E-07	1.46E-08
Toluene	38.0	8.60E-06	2.20E-05	8.00E-03	3.13E-03	1.56E-01	6.60202E-05	2.39E-06
Xylenes	18.0	1.00E-05	2.20E-05	8.00E-03	3.64E-03	1.82E-01	3.63636E-05	1.32E-06

Parameters of model pond	
Length (m)	2
Width (m)	2
Depth (m)	0.5
Area (m ²)	4
CF (m/cm)	100
CF (hour/sec)	3600
H (Mixing Height of Man, m)	2
Average wind speed (m/s)	4.6

APPENDIX C

Risk Calculations Tables for Alburn, U. S. Drum and Unnamed Parcel

Table A-1.
TOXICITY FACTORS FOR CHEMICALS OF POTENTIAL CONCERN FOR LAKE CALUMET CLUSTER SITE:
ALBURN

COPC	Carcinogenic Risk						Noncarcinogenic Risk			
	Ingestion Slope Factor	EPC for Soil	EPC for Sediment	EPC for SW	EPC for GW	EPC for GW In air	Inhalation Reference Dose	Dermal Reference Dose	Volatiles Inhalation Rel. Dose	Volatiles Inhalation Rel. Factor
Arsenic	(kg-day/mg) 1.50E+00	(ug/kg) 1.62E+04	(ug/kg) 1.04E+05	(ug/L) 1.22E+02	(ug/L) 1.22E+02	(g/m ³) 1.72E-07	(mg/kg-day) 4.00E-04	(mg/kg-day) 4.00E-04	(ug/m ³) 0.00E+00	(m ³ /ug) 4.30E-03
Beryllium	(kg-day/mg) 5.50E-02	(ug/kg) 8.30E+04	(ug/kg) 8.30E+04	(ug/L) 2.40E+03	(ug/L) 2.40E+03	(g/m ³) 1.72E-07	(mg/kg-day) 2.90E-02	(mg/kg-day) 5.50E-02	(ug/m ³) 0.00E+00	(m ³ /ug) 8.29E-06
Benz(a)anthracene	(kg-day/mg) 7.30E-01	(ug/kg) 5.09E+03	(ug/kg) 5.09E+03	(ug/L) 8.00E+00	(ug/L) 8.00E+00	(g/m ³) 1.72E-07	(mg/kg-day) 3.10E-01	(mg/kg-day) 7.30E-01	(ug/m ³) 8.86E-05	(m ³ /ug) 8.86E-05
Benz(b)fluoranthene	(kg-day/mg) 7.30E-01	(ug/kg) 5.84E+03	(ug/kg) 5.84E+03	(ug/L) 1.00E+01	(ug/L) 1.00E+01	(g/m ³) 1.72E-07	(mg/kg-day) 3.10E-01	(mg/kg-day) 7.30E-01	(ug/m ³) 8.86E-05	(m ³ /ug) 8.86E-05
Benz(k)fluoranthene	(kg-day/mg) 7.30E-02	(ug/kg) 7.30E+00	(ug/kg) 7.30E+00	(ug/L) 9.00E+00	(ug/L) 9.00E+00	(g/m ³) 1.72E-07	(mg/kg-day) 3.10E-02	(mg/kg-day) 7.30E-02	(ug/m ³) 8.86E-04	(m ³ /ug) 8.86E-04
Benzofluoranthene	(kg-day/mg) 7.30E+00	(ug/kg) 4.43E+03	(ug/kg) 4.43E+03	(ug/L) 8.00E+00	(ug/L) 8.00E+00	(g/m ³) 1.72E-07	(mg/kg-day) 3.10E-03	(mg/kg-day) 7.30E-03	(ug/m ³) 8.86E-04	(m ³ /ug) 8.86E-04
Chrysene	(kg-day/mg) 7.30E-03	(ug/kg) 1.51E+03	(ug/kg) 1.51E+03	(ug/L) 8.00E+00	(ug/L) 8.00E+00	(g/m ³) 1.72E-07	(mg/kg-day) 3.10E-03	(mg/kg-day) 7.30E-03	(ug/m ³) 8.86E-04	(m ³ /ug) 8.86E-04
Dibenz(a,h)anthracene	(kg-day/mg) 7.30E+00	(ug/kg) 2.93E+03	(ug/kg) 2.93E+03	(ug/L) 2.00E+01	(ug/L) 2.00E+01	(g/m ³) 1.72E-07	(mg/kg-day) 3.10E-01	(mg/kg-day) 7.30E-01	(ug/m ³) 8.86E-05	(m ³ /ug) 8.86E-05
Indeno(1,2,3-cd)pyrene	(kg-day/mg) 1.10E+00	(ug/kg) 8.81E+02	(ug/kg) 8.81E+02	(ug/L) 2.80E+02	(ug/L) 2.80E+02	(g/m ³) 1.72E-07	(mg/kg-day) 1.10E+00	(mg/kg-day) 1.10E+00	(ug/m ³) 3.31E-04	(m ³ /ug) 3.31E-04
Bis(2-chloroethyl) Ether	(kg-day/mg) 1.40E-02	(ug/kg) 4.50E+00	(ug/kg) 4.50E+00	(ug/L) 7.90E+01	(ug/L) 7.90E+01	(g/m ³) 1.72E-07	(mg/kg-day) 4.50E+00	(mg/kg-day) 4.50E+00	(ug/m ³) 1.29E-03	(m ³ /ug) 1.29E-03
Heptachlor	(kg-day/mg) 4.50E+00	(ug/kg) 7.50E-03	(ug/kg) 7.50E-03	(ug/L) 1.70E+02	(ug/L) 1.70E+02	(g/m ³) 1.72E-07	(mg/kg-day) 1.65E-03	(mg/kg-day) 7.50E-03	(ug/m ³) 4.71E-07	(m ³ /ug) 4.71E-07
Methylene chloride	(kg-day/mg) 4.90E-03	(ug/kg) 5.47E+04	(ug/kg) 5.47E+04	(ug/L) 6.00E+00	(ug/L) 6.00E+00	(g/m ³) 1.72E-07	(mg/kg-day) 2.00E-03	(mg/kg-day) 5.20E-02	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
N-Nitrosodiphenylamine	(kg-day/mg) 5.20E-02	(ug/kg) 5.68E+04	(ug/kg) 5.68E+04	(ug/L) 3.58E+02	(ug/L) 3.58E+02	(g/m ³) 1.72E-07	(mg/kg-day) 1.43E-04	(mg/kg-day) 7.00E-02	(ug/m ³) 5.01E-01	(m ³ /ug) 5.01E-01
Tetrachloroethene	(kg-day/mg) 1.10E-02	(ug/kg) 8.35E+04	(ug/kg) 8.35E+04	(ug/L) 6.30E+03	(ug/L) 6.30E+03	(g/m ³) 1.72E-07	(mg/kg-day) 5.71E-06	(mg/kg-day) 2.00E-03	(ug/m ³) 2.00E-02	(m ³ /ug) 2.00E-02
Vinyl Chloride	(kg-day/mg) 7.20E-01	(ug/kg) 5.08E+04	(ug/kg) 5.08E+04	(ug/L) 2.19E+01	(ug/L) 2.19E+01	(g/m ³) 1.72E-07	(mg/kg-day) 1.50E+00	(mg/kg-day) 1.50E+00	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Total PCBs	(kg-day/mg) 2.00E+00	(ug/kg) 1.94E+03	(ug/kg) 1.94E+03	(ug/L) 3.52E+02	(ug/L) 3.52E+02	(g/m ³) 1.72E-07	(mg/kg-day) 1.43E-05	(mg/kg-day) 4.80E-02	(ug/m ³) 5.01E-02	(m ³ /ug) 5.01E-02
Noncarcinogenic Risk										
COPC	Ingestion Reference Dose	EPC for Soil	EPC for Sediment	EPC for SW	EPC for GW	EPC for GW In air	Inhalation Reference Dose	Dermal Reference Dose	Volatiles Inhalation Rel. Dose	Volatiles Inhalation Rel. Factor
Anilinity	(mg/kg-day) 4.00E-04	(ug/kg) 1.58E+04	(ug/kg) 1.04E+05	(ug/L) 6.60E+00	(ug/L) 6.60E+00	(g/m ³) 1.72E-07	(mg/kg-day) 4.00E-04	(mg/kg-day) 4.00E-04	(ug/m ³) 0.00E+00	(m ³ /ug) 4.30E-03
Arsenic	(mg/kg-day) 3.00E-04	(ug/kg) 1.62E+04	(ug/kg) 1.04E+05	(ug/L) 1.22E+02	(ug/L) 1.22E+02	(g/m ³) 1.72E-07	(mg/kg-day) 3.00E-04	(mg/kg-day) 3.00E-04	(ug/m ³) 0.00E+00	(m ³ /ug) 4.30E-03
Barium	(mg/kg-day) 7.00E-02	(ug/kg) 3.64E+05	(ug/kg) 3.64E+05	(ug/L) 3.58E+02	(ug/L) 3.58E+02	(g/m ³) 1.72E-07	(mg/kg-day) 1.43E-04	(mg/kg-day) 7.00E-02	(ug/m ³) 5.01E-01	(m ³ /ug) 5.01E-01
Beryllium	(mg/kg-day) 2.00E-03	(ug/kg) 1.55E+03	(ug/kg) 1.04E+05	(ug/L) 6.30E+03	(ug/L) 6.30E+03	(g/m ³) 1.72E-07	(mg/kg-day) 5.71E-06	(mg/kg-day) 2.00E-03	(ug/m ³) 2.00E-02	(m ³ /ug) 2.00E-02
Cadmium	(mg/kg-day) 5.00E-04	(ug/kg) 7.31E+03	(ug/kg) 5.37E+05	(ug/L) 2.19E+01	(ug/L) 2.19E+01	(g/m ³) 1.72E-07	(mg/kg-day) 1.50E+00	(mg/kg-day) 1.50E+00	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Chromium	(mg/kg-day) 1.50E+00	(ug/kg) 2.61E+05	(ug/kg) 6.37E+05	(ug/L) 3.52E+02	(ug/L) 3.52E+02	(g/m ³) 1.72E-07	(mg/kg-day) 1.43E-05	(mg/kg-day) 4.80E-02	(ug/m ³) 5.01E-02	(m ³ /ug) 5.01E-02
Manganese	(mg/kg-day) 4.60E-02	(ug/kg) 3.90E+06	(ug/kg) 3.90E+06	(ug/L) 2.79E+03	(ug/L) 2.79E+03	(g/m ³) 1.72E-07	(mg/kg-day) 8.60E-05	(mg/kg-day) 0.00E+00	(ug/m ³) 3.01E-01	(m ³ /ug) 3.01E-01
Mercury	(mg/kg-day) 2.00E-02	(ug/kg) 8.29E+04	(ug/kg) 8.29E+04	(ug/L) 3.60E+00	(ug/L) 3.60E+00	(g/m ³) 1.72E-07	(mg/kg-day) 2.00E-02	(mg/kg-day) 2.00E-02	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Nickel	(mg/kg-day) 8.00E-05	(ug/kg) 7.00E+03	(ug/kg) 7.00E+03	(ug/L) 2.54E+02	(ug/L) 2.54E+02	(g/m ³) 1.72E-07	(mg/kg-day) 7.00E-03	(mg/kg-day) 7.00E-03	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Vanadium	(mg/kg-day) 7.00E-03	(ug/kg) 8.29E+04	(ug/kg) 8.29E+04	(ug/L) 6.94E+03	(ug/L) 6.94E+03	(g/m ³) 1.72E-07	(mg/kg-day) 3.00E-01	(mg/kg-day) 3.00E-01	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Zinc	(mg/kg-day) 3.00E-01	(ug/kg) 4.15E+04	(ug/kg) 4.15E+04	(ug/L) 7.90E+01	(ug/L) 7.90E+01	(g/m ³) 1.72E-07	(mg/kg-day) 2.00E-02	(mg/kg-day) 2.00E-02	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Bis(2-ethylhexyl)phthalate	(mg/kg-day) 2.00E-02	(ug/kg) 8.29E+04	(ug/kg) 8.29E+04	(ug/L) 1.70E+02	(ug/L) 1.70E+02	(g/m ³) 1.72E-07	(mg/kg-day) 2.00E-01	(mg/kg-day) 1.00E-01	(ug/m ³) 7.00E+02	(m ³ /ug) 7.00E+02
Carbon disulfide	(mg/kg-day) 1.00E-01	(ug/kg) 4.15E+04	(ug/kg) 4.15E+04	(ug/L) 3.20E+02	(ug/L) 3.20E+02	(g/m ³) 1.72E-07	(mg/kg-day) 5.71E-03	(mg/kg-day) 2.00E-02	(ug/m ³) 2.00E+01	(m ³ /ug) 2.00E+01
Chlorobenzene	(mg/kg-day) 2.00E-02	(ug/kg) 4.15E+04	(ug/kg) 4.15E+04	(ug/L) 1.70E+02	(ug/L) 1.70E+02	(g/m ³) 1.72E-07	(mg/kg-day) 5.71E-03	(mg/kg-day) 2.00E-02	(ug/m ³) 2.00E+01	(m ³ /ug) 2.00E+01
2,4-Dimethylphenol	(mg/kg-day) 2.00E-02	(ug/kg) 4.72E+06	(ug/kg) 4.72E+06	(ug/L) 5.80E+03	(ug/L) 5.80E+03	(g/m ³) 1.72E-07	(mg/kg-day) 2.86E-01	(mg/kg-day) 2.00E-02	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Ethylbenzene	(mg/kg-day) 1.00E-01	(ug/kg) 3.97E+00	(ug/kg) 3.97E+00	(ug/L) 3.00E-01	(ug/L) 3.00E-01	(g/m ³) 1.72E-07	(mg/kg-day) 8.57E-01	(mg/kg-day) 5.00E-04	(ug/m ³) 3.00E+03	(m ³ /ug) 3.00E+03
Heptachlor	(mg/kg-day) 5.00E-04	(ug/kg) 5.47E+04	(ug/kg) 5.47E+04	(ug/L) 1.70E+02	(ug/L) 1.70E+02	(g/m ³) 1.72E-07	(mg/kg-day) 8.57E-01	(mg/kg-day) 8.00E-02	(ug/m ³) 3.00E+03	(m ³ /ug) 3.00E+03
Methylene chloride	(mg/kg-day) 6.00E-02	(ug/kg) 5.68E+04	(ug/kg) 5.68E+04	(ug/L) 4.20E+02	(ug/L) 4.20E+02	(g/m ³) 1.72E-07	(mg/kg-day) 8.57E-04	(mg/kg-day) 1.00E-02	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Naphthalene	(mg/kg-day) 2.00E-02	(ug/kg) 1.87E+06	(ug/kg) 1.87E+06	(ug/L) 3.80E+04	(ug/L) 3.80E+04	(g/m ³) 1.72E-07	(mg/kg-day) 1.14E-01	(mg/kg-day) 2.00E-01	(ug/m ³) 3.99E+02	(m ³ /ug) 3.99E+02
Tetrachloroethene	(mg/kg-day) 6.00E-03	(ug/kg) 5.08E+04	(ug/kg) 5.08E+04	(ug/L) 3.80E+04	(ug/L) 3.80E+04	(g/m ³) 1.72E-07	(mg/kg-day) 2.80E-02	(mg/kg-day) 3.00E-03	(ug/m ³) 1.02E+02	(m ³ /ug) 1.02E+02
Trichloroethene	(mg/kg-day) 2.00E-01	(ug/kg) 5.08E+04	(ug/kg) 5.08E+04	(ug/L) 1.80E+04	(ug/L) 1.80E+04	(g/m ³) 1.72E-07	(mg/kg-day) 2.80E-02	(mg/kg-day) 2.00E+00	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Toluene	(mg/kg-day) 3.00E-03	(ug/kg) 2.50E+07	(ug/kg) 2.50E+07	(ug/L) 1.80E+04	(ug/L) 1.80E+04	(g/m ³) 1.72E-07	(mg/kg-day) 2.80E-02	(mg/kg-day) 2.00E+00	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Vinyl Chloride	(mg/kg-day) 2.00E+00	(ug/kg) 2.50E+07	(ug/kg) 2.50E+07	(ug/L) 1.80E+04	(ug/L) 1.80E+04	(g/m ³) 1.72E-07	(mg/kg-day) 2.80E-02	(mg/kg-day) 2.00E+00	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00
Xylenes	(mg/kg-day) 2.00E+00	(ug/kg) 2.50E+07	(ug/kg) 2.50E+07	(ug/L) 1.80E+04	(ug/L) 1.80E+04	(g/m ³) 1.72E-07	(mg/kg-day) 2.80E-02	(mg/kg-day) 2.00E+00	(ug/m ³) 0.00E+00	(m ³ /ug) 0.00E+00

Table A-1.
TOXICITY FACTORS FOR CHEMICALS OF POTENTIAL CONCERN FOR LAKE CALUMET CLUSTER SITE:
ALBURN

Note:
COPC: Contaminants of potential concern
EPC: Exposure point concentration

Table A-2.
SOIL INGESTION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
ALBURN

Carcinogenic Risk					
$LADD = EPC \times FI \times IRS \times EF \times ED \times CF / (BW \times ATc)$					
EPC=exposure point concentration (ug/kg)					
FI=fraction ingested from contaminated source					
IRS=soil ingestion rate (mg/day)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁹ kg/ug					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
ELCR=LADDxSFO					
SFO=oral cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
IRS (mg/day)	50	480	50	480	50
FI	0.5	1	0.5	1	0.5
EF (day/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
Atc (days)	25550	25550	25550	25550	25550
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09
Noncarcinogenic Risk					
$ADD = EPC \times FI \times IRS \times EF \times ED \times CF / (BW \times ATn)$					
EPC=exposure point concentration (ug/kg)					
FI=fraction ingested from contaminated source					
IRS=soil ingestion rate (mg/day)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
BW=body weight (kg)					
ATn=averaging time for noncarcinogens (days)					
$HQ = ADD / RfDo$					
ADD=average daily dose (mg/kg-day)					
RfDo=Ingestion reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
IRS (mg/day)	50	480	50	480	50
FI	0.5	1	0.5	1	0.5
EF (day/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
ATn (days)	9125	40	9125	9125	9125
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table A-3.
SOIL INGESTION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: ALBURN

Carcinogenic Risk											
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker		
	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	
Arsenic	2.93E-07	4.24E-07	1.30E-07	1.95E-07	1.41E-06	2.12E-06	1.09E-06	1.63E-06	1.13E-07	1.70E-07	
Beryllium	2.72E-08	0.00E+00	1.25E-08	0.00E+00	1.36E-07	0.00E+00	1.04E-07	0.00E+00	1.09E-08	0.00E+00	
Benzene	1.45E-06	7.98E-08	6.99E-07	3.68E-08	7.25E-06	3.99E-07	5.57E-06	3.06E-07	5.80E-07	3.19E-08	
Benzol(a)anthracene	8.90E-08	6.50E-08	4.10E-08	2.99E-08	4.45E-07	3.25E-07	3.42E-07	2.49E-07	3.56E-08	2.80E-08	
Benzol(b)fluoranthene	1.02E-07	7.45E-08	4.70E-08	2.43E-08	5.10E-07	3.73E-07	3.92E-07	2.86E-07	4.08E-08	2.98E-08	
Benzol(e)pyrene	7.74E-08	5.85E-07	3.57E-08	2.60E-07	5.87E-07	2.83E-06	2.97E-07	2.17E-06	3.10E-08	2.26E-07	
Biphenyl(a)anthracene	2.84E-08	1.93E-07	1.22E-08	8.88E-08	1.32E-07	9.84E-07	1.01E-07	7.40E-07	1.08E-08	7.71E-08	
Indeno(1,2,3-cd)pyrene	6.12E-08	3.74E-08	2.95E-08	1.72E-08	2.66E-07	1.87E-07	1.97E-07	1.44E-07	2.05E-08	1.59E-08	
Bis(2-Chlorophenyl) Ether	1.84E-08	1.89E-08	7.10E-08	7.81E-09	7.70E-08	8.47E-08	5.91E-08	6.50E-08	6.16E-09	6.78E-09	
Methylene chloride	9.57E-07	7.17E-09	4.41E-07	3.31E-09	4.78E-06	3.59E-08	3.67E-06	2.75E-08	3.83E-07	2.87E-09	
Tetrachloroethene	9.92E-07	5.16E-08	4.57E-07	2.38E-08	4.96E-06	2.58E-07	3.81E-06	1.98E-07	3.97E-07	2.06E-08	
Trichloroethene	1.46E-06	1.60E-08	6.72E-07	7.39E-09	7.29E-06	8.02E-08	5.80E-06	6.16E-08	5.84E-07	6.42E-09	
Vinyl Chloride	8.88E-07	8.39E-07	4.09E-07	2.95E-07	4.44E-06	3.20E-06	3.41E-06	2.45E-06	3.55E-07	2.56E-07	
Total PCBs	3.39E-08	6.77E-08	1.66E-08	3.12E-08	1.69E-07	3.39E-07	1.30E-07	2.60E-07	1.95E-08	2.71E-08	

Noncarcinogenic Risk											
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker		
	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	
Antimony	7.75E-07	1.94E-03	8.15E-06	2.04E-01	3.68E-06	9.59E-03	2.99E-06	7.44E-03	3.10E-07	7.75E-04	
Arsenic	7.92E-07	2.64E-03	8.32E-05	2.77E-01	3.96E-06	1.32E-02	3.04E-06	1.01E-02	3.17E-07	1.06E-03	
Barium	1.80E-05	2.88E-04	1.97E-03	2.82E-02	9.39E-05	1.34E-03	7.21E-05	1.09E-03	7.51E-06	1.07E-04	
Beryllium	7.81E-08	3.80E-05	8.00E-06	4.00E-03	3.80E-07	1.90E-04	2.92E-07	1.48E-04	3.04E-08	1.52E-05	
Cadmium	3.58E-07	7.15E-04	3.76E-05	7.52E-02	1.79E-06	3.58E-03	1.37E-06	2.75E-03	1.49E-07	2.86E-04	
Chromium	1.28E-05	8.52E-06	1.34E-03	8.98E-04	6.39E-05	4.26E-06	4.91E-05	3.27E-05	5.11E-06	3.41E-06	
Manganese	1.91E-04	4.15E-03	2.01E-02	4.36E-01	9.54E-04	2.07E-02	7.39E-04	1.59E-02	7.83E-05	1.66E-03	
Carbon disulfide	4.05E-06	4.05E-06	4.26E-04	4.26E-03	2.03E-05	2.03E-04	1.56E-05	1.56E-04	1.62E-06	1.82E-05	
Chlorobenzene	2.03E-06	1.02E-04	2.13E-04	1.07E-02	1.02E-05	5.06E-04	7.80E-06	3.90E-04	8.19E-07	4.06E-05	
Ethylbenzene	2.31E-04	2.31E-03	2.45E-02	2.43E-01	1.16E-03	1.16E-02	6.87E-04	8.87E-03	9.24E-05	9.24E-05	
Heptachlor	1.94E-10	3.80E-07	2.04E-08	4.08E-05	9.71E-10	1.94E-06	7.48E-10	1.49E-06	7.77E-11	1.55E-07	
Methylene chloride	2.68E-06	4.48E-05	2.82E-04	4.89E-03	1.34E-06	2.83E-04	1.39E-05	1.71E-04	1.07E-06	1.79E-05	
Tetrachloroethene	2.78E-06	2.78E-04	2.92E-04	2.92E-02	1.39E-05	1.39E-03	1.07E-05	1.07E-03	1.11E-06	1.11E-04	
Trichloroethene	4.08E-06	6.81E-04	4.29E-04	7.16E-02	2.04E-05	3.40E-03	1.57E-05	2.61E-03	1.83E-06	2.72E-04	
Toluene	8.17E-05	4.89E-04	8.59E-03	4.29E-02	4.08E-04	2.04E-03	3.14E-04	1.57E-03	3.27E-05	1.83E-04	
Vinyl Chloride	2.49E-06	8.29E-04	2.61E-04	6.71E-02	1.24E-05	4.14E-03	9.54E-06	3.18E-03	9.94E-07	3.31E-04	
Xylenes	1.22E-03	6.12E-04	1.29E-01	6.43E-02	1.24E-03	3.06E-03	4.70E-03	2.35E-03	4.88E-04	2.45E-04	

Summary			
ELCR for this pathway	On-site Worker	Construction Worker	Industrial / Commercial Worker
HQ for this pathway	8.30E-03	8.72E-01	4.16E-02
Notes:			
ELCR: Excess lifetime cancer risks			
HQ: Hazard Index			
COPC: Contaminants of potential concern			
LADD: Lifetime average daily dose			
ADD: Average daily dose			
HQ: Hazard quotient			
Bold shaded area indicated ELCR or HQ exceedances for the receptor			

ELCR for this pathway	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
HQ for this pathway	8.30E-03	8.72E-01	4.16E-02	3.19E-02	3.32E-03

Table A-4.
SOIL DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE: ALBURN

Carcinogenic Risk					
LADD=EPC_{soil}SAxAFxABSxEFxEDxCF/(BWxATc)					
EPC=exposure point concentration (ug/kg)					
SA=body surface area (cm ² /day)					
AF=soil adherence factor (mg/cm ²)					
ABS=dermal adsorption factor (unitless)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor (10 ⁻⁹ kg/ug)					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
ELCR=LADDxSFd					
SFd=dermal cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ² /day)	3300	3300	3300	3300	3300
AF(mg/cm ²)	0.2	0.2	0.2	0.2	0.2
ABS	Chemical Specific				
Inorganics	0.01	0.01	0.01	0.01	0.01
Bis(2-ethylhexyl)phthalate	0.4	0.4	0.4	0.4	0.4
Tetrachloroethene	0.03	0.03	0.03	0.03	0.03
Trichloroethene	0.03	0.03	0.03	0.03	0.03
Vinyl chloride	0.03	0.03	0.03	0.03	0.03
EF (day/year) for Soil	50	10	20	30	250
EF (day/year) for Sediment	5			5	5
ET (hour/day)	5	8	8	8	8
ED (years)	25	25	25	1	25
BW (kg)	70	70	70	70	70
Atc (days) - for Soil	25550	25550	25550	25550	25550
Atc (days) - for Sediment	25550			25550	25550
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table A-4.
SOIL DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE: ALBURN

Noncarcinogenic Risk					
$ADD = EPC \times SA \times AF \times ABS \times EF \times ED \times CF / (BW \times ATn) \text{ - Soil and Sediment}$					
EPC=exposure point concentration (ug/kg)					
SA=body surface area (cm ² /day)					
AF=soil adherence factor (mg/cm ²)					
ABS=dermal adsorption factor					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁹ kg/mg					
BW=body weight (kg)					
ATn =averaging time for noncarcinogens (days)					
HQ=ADD/RfD _o					
ADD=average daily dose (mg/kg-day)					
RfD _o =dermal reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ² /day)	3300	3300	3300	3300	3300
AF(mg/cm ²)	0.2	0.2	0.2	0.2	0.2
ABS	Chemical Specific				
Inorganics	0.01	0.01	0.01	0.01	0.01
Bis(2-ethylhexyl)phthalate	0.4	0.4	0.4	0.4	0.4
Tetrachloroethene	0.03	0.03	0.03	0.03	0.03
Trichloroethene	0.03	0.03	0.03	0.03	0.03
Vinyl chloride	0.03	0.03	0.03	0.03	0.03
Others	0	0	0	0	0
EF (day/year) for Soil	50	10	20	30	250
EF (day/year) for Sediment	5			5	5
ET (hour/day)	5	8	8	8	8
ED (years)	25	25	25	1	25
BW (kg)	70	70	70	70	70
ATn (days) - for Soil	9125	9125	9125	40	9125
ATn (days) - for Sediment	9125			40	9125
Conversion Factor kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table A-5.
WATER DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE: ALBURN

Carcinogenic Risk					
$LADD = EPC \times SA \times PC \times ET \times EF \times ED \times CF / (BW \times ATc)$					
EPC = exposure point concentration (ug/L)					
SA = skin surface area (cm ²)					
PC = Permeability Constant (cm/hr)					
EF = exposure frequency (days/year)					
ET = exposure time (hour/day)					
ED = exposure duration (years)					
CF = conversion factor 10 ⁻⁸ (L-mg/cm ² -ug)					
BW = body weight (kg)					
ATc = averaging time for carcinogens (days)					
ELCR = LADD x SFd					
SFd = dermal cancer slope factor (kg-day/mg)					
LADD = lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ²)	3300	3300	3300	3300	3300
PC (cm/hr)	Chemical Specific				
Inorganic	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Benzo(a)pyrene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Benzo(a)anthracene	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01
Benzo(b)fluoranthene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Dibenzo(a,h)anthracene	2.70E+00	2.70E+00	2.70E+00	2.70E+00	2.70E+00
Indeno(1,2,3-cd)pyrene	1.90E+00	1.90E+00	1.90E+00	1.90E+00	1.90E+00
Benzo(k)fluoranthene					
Chrysene	8.10E-01	8.10E-01	8.10E-01	8.10E-01	8.10E-01
Vinyl chloride	7.30E-03	7.30E-03	7.30E-03	7.30E-03	7.30E-03
bis(2-ethylhexyl)phthalate	3.30E-02	3.30E-02	3.30E-02	3.30E-02	3.30E-02
Tetrachloroethene	4.80E-02	4.80E-02	4.80E-02	4.80E-02	4.80E-02
Trichloroethene	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.60E-02
EF (day/year) for SW & GW	5			5	5
ET (hour/day)	1	1	1	1	1
ED (years)	25			1	25
BW (kg)	70	70	70	70	70
ATc (days) - for SW & GW	25550			25550	25550
Conversion Factor (L-mg/cm ² -ug)	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06

Table A-5.
WATER DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE: ALBURN

Noncarcinogenic Risk					
$ADD = EPC \times SA \times PC \times ET \times EF \times ED \times CF / (BW \times ATn)$					
EPC=exposure point concentration (ug/L)					
SA = Skin surface area (cm ²)					
PC=Permeability Constant (cm/hr)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁶ (L-mg/cm ² -ug)					
CF=conversion factor 10 ⁻⁶ (L-mg/cm ² -ug)					
BW=body weight (kg)					
ATn =averaging time for noncarcinogens (days)					
HQ=ADD/RfDo					
ADD=average daily dose (mg/kg-day)					
RfDd=dermal reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ²)	3300	3300	3300	3300	3300
PC (cm/hr)	Chemical Specific				
Inorganic	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Benzo(a)pyrene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Benzo(a)anthracene	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01
Benzo(b)fluoranthene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Dibenzo(a,h)anthracene	2.70E+00	2.70E+00	2.70E+00	2.70E+00	2.70E+00
Indeno(1,2,3-cd)pyrene	1.90E+00	1.90E+00	1.90E+00	1.90E+00	1.90E+00
Benzo(k)fluoranthene					
Chrysene	8.10E-01	8.10E-01	8.10E-01	8.10E-01	8.10E-01
Vinyl chloride	7.30E-03	7.30E-03	7.30E-03	7.30E-03	7.30E-03
bis(2-ethylhexyl)phthalate	3.30E-02	3.30E-02	3.30E-02	3.30E-02	3.30E-02
Tetrachloroethene	4.80E-02	4.80E-02	4.80E-02	4.80E-02	4.80E-02
Trichloroethene	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.60E-02
EF (day/year) for SW & GW	5			5	5
ET (hour/day)	1	8	8	1	1
ED (years)	25			1	25
BW (kg)	70	70	70	70	70
Atn (days) - for SW & GW	9125			40	9125
Conversion Factor (L-mg/cm ² -ug)	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06

Table A-6.
DERMAL EXPOSURE EVALUATION FOR SOIL FOR LAKE CALUMET CLUSTER SITE: ALBURN

	Dermal Adsorp. Factors (ABS)	Carcinogenic Risk									
		On-site Worker		Mower		Landscape Worker		Construction Worker		Industrial/Commercial Worker	
		LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR
GOPC											
Arsenic	3.00E-02	2.24E-07	3.36E-07	4.48E-08	6.72E-08	8.96E-08	1.34E-07	5.36E-09	8.06E-09	1.12E-05	1.68E-06
Beryllium	1.00E-02	7.17E-09	0.00E+00	1.43E-09	0.00E+00	2.87E-09	0.00E+00	1.72E-10	0.00E+00	3.59E-06	0.00E+00
Benzene	3.00E-02	1.15E-08	6.32E-08	2.30E-07	1.26E-06	4.60E-07	2.53E-06	2.76E-08	1.52E-09	5.75E-08	3.16E-07
Bis(2-Chloroethyl) Ether	1.00E-02	4.07E-08	4.47E-08	8.13E-10	8.94E-10	1.63E-09	1.79E-09	9.76E-11	1.07E-10	2.03E-08	2.24E-08
Methylene chloride	3.00E-02	7.58E-07	5.84E-08	1.52E-07	1.14E-09	3.03E-07	2.27E-09	1.92E-08	1.36E-10	3.79E-06	2.84E-08
Tetrachloroethene	3.00E-02	7.85E-07	4.08E-08	1.57E-07	8.17E-09	3.14E-07	1.63E-06	1.89E-08	8.80E-10	3.93E-06	2.04E-07
Trichloroethene	3.00E-02	1.16E-06	1.27E-08	2.31E-07	2.54E-09	4.62E-07	5.04E-09	2.77E-08	3.06E-10	5.78E-06	6.35E-08
Vinyl Chloride	3.00E-02	7.03E-07	5.06E-07	1.41E-07	1.01E-07	2.81E-07	2.02E-07	1.69E-08	1.21E-08	3.52E-06	2.81E-06
Total PCBs	1.40E-01	1.25E-07	2.50E-07	2.80E-08	5.01E-08	5.01E-06	1.00E-07	3.00E-08	6.01E-08	6.26E-07	1.25E-06
Noncarcinogenic Risk											
	Dermal Adsorp. Factors (ABS)	On-site Worker		Mower		Landscape Worker		Construction Worker		Industrial/Commercial Worker	
		LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR
		ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ
GOPC											
Antimony	1.00E-02	2.05E-07	5.12E-04	4.09E-08	1.02E-04	8.19E-08	2.05E-04	1.12E-08	2.80E-03	1.02E-06	2.58E-03
Arsenic	3.00E-02	6.27E-07	2.09E-03	1.25E-07	4.18E-04	2.51E-07	8.96E-04	3.43E-06	1.14E-02	3.14E-06	1.05E-02
Barium	1.00E-02	4.98E-05	7.08E-05	9.92E-07	1.42E-05	1.88E-06	2.83E-06	2.71E-05	3.88E-04	2.48E-05	3.54E-04
Beryllium	1.00E-02	2.01E-08	1.00E-05	4.03E-06	2.01E-06	8.03E-08	4.03E-06	1.10E-07	5.50E-03	1.00E-07	6.02E-05
Cadmium	1.00E-02	9.44E-08	1.89E-04	1.89E-08	3.78E-06	3.78E-08	7.55E-06	8.17E-07	1.03E-03	4.72E-07	9.44E-04
Chromium	1.00E-02	3.37E-08	2.89E-08	6.75E-07	4.50E-07	1.36E-08	9.03E-07	1.85E-05	1.23E-03	1.69E-05	1.12E-05
Manganese	1.00E-02	5.04E-05	1.10E-03	1.01E-05	2.19E-04	2.02E-05	4.38E-04	2.78E-04	8.00E-03	2.32E-04	5.48E-03
Carbon disulfide	3.00E-02	3.21E-06	3.21E-06	8.42E-07	6.42E-06	1.28E-06	1.28E-06	1.78E-05	1.78E-04	1.61E-05	1.61E-04
Chlorobenzene	3.00E-02	1.81E-05	8.04E-05	3.22E-07	1.61E-05	6.43E-07	3.22E-05	8.80E-08	4.40E-04	8.04E-08	4.02E-04
Ethylbenzene	3.00E-02	1.83E-04	1.83E-03	3.66E-05	3.66E-04	7.32E-05	7.32E-04	1.00E-03	1.00E-02	9.15E-04	9.15E-03
Heptachlor	1.00E-01	6.13E-10	1.03E-08	1.03E-10	2.05E-07	2.05E-10	4.10E-07	2.81E-09	6.61E-03	2.58E-09	5.13E-06
Methylene chloride	3.00E-02	2.12E-06	3.64E-05	4.24E-07	7.07E-06	8.49E-07	1.41E-05	1.16E-05	1.94E-04	1.08E-05	1.77E-04
Tetrachloroethene	3.00E-02	2.20E-06	2.20E-04	4.40E-07	4.40E-05	8.80E-07	8.80E-05	1.20E-05	1.20E-03	1.62E-05	2.70E-03
Trichloroethene	3.00E-02	9.24E-06	5.39E-04	8.47E-07	1.08E-04	1.29E-06	2.16E-04	1.77E-05	2.85E-03	3.28E-04	1.62E-03
Toluene	3.00E-02	6.47E-05	3.23E-04	1.29E-05	6.47E-05	2.59E-05	1.29E-04	3.64E-04	1.77E-03	3.28E-04	1.62E-03
Vinyl Chloride	3.00E-02	1.97E-06	6.55E-04	3.94E-07	1.31E-04	7.87E-07	2.62E-04	1.08E-06	3.59E-03	9.84E-06	3.28E-03
Xylenes	3.00E-02	9.69E-04	4.84E-04	1.94E-04	9.69E-05	3.87E-04	1.94E-04	5.30E-03	2.65E-03	4.84E-03	2.42E-03
Summary											
ELCR for this pathway		On-site Worker		Mower		Landscape Worker		Construction Worker		Industrial/Commercial Worker	
HI for this pathway		1.22E-06		2.44E-07		4.88E-07		2.83E-08		1.63E-06	
Notes:		8.17E-03		1.63E-03		3.27E-03		4.47E-02		4.08E-02	
ELCR: Exposure lifetime cancer risk											
HI: Hazard Index											
GOPC: Confirms potential concern											
LADD: Lifetime average daily dose											
ADD: Average daily dose											
HQ: Hazard quotient											

Table A-7.
DERMAL EXPOSURE EVALUATION FOR SEDIMENTS FOR LAKE CALUMET CLUSTER SITE: ALBURN

Carcinogenic Risk							
	Dermal Adsorp. Factors	On-site Worker		Construction Worker		Industrial / Commercial Worker	
		LADD	ELCR	LADD	ELCR	LADD	ELCR
COPC							
Arsenic	3.00E-02	1.44E-07	2.16E-07	5.76E-09	8.64E-09	1.44E-07	2.16E-07
Chrysene	0.00E+00	1.92E-08	1.40E-10	8.86E-09	6.47E-11	9.61E-08	7.02E-10
Noncarcinogenic Risk							
	Dermal Adsorp. Factors	On-site Worker		Construction Worker		Industrial / Commercial Worker	
		ADD	HQ	ADD	HQ	ADD	HQ
COPC							
Arsenic	3.00E-02	4.03E-07	1.34E-03	3.68E-06	1.23E-02	4.03E-07	1.34E-03
Chromium	1.00E-02	6.94E-07	4.62E-07	6.33E-06	4.22E-06	6.94E-07	4.62E-07
Summary							
ELCR for this pathway=		On-site Worker		Construction Worker		Industrial / Commercial Worker	
HI for this pathway=		2.16E-07		8.70E-09		2.17E-07	
		1.34E-03		1.23E-02		1.34E-03	

Notes:

ELCR: Excess lifetime cancer risks
 HI: Hazard index
 COPC: Contaminants of potential concern
 LADD: Lifetime average daily dose
 ADD: Average daily dose
 HQ: Hazard quotient

Table A-8.
DERMAL EXPOSURE EVALUATION FOR SURFACE WATER
FOR LAKE CALUMET CLUSTER SITE: ALBURN

Carcinogenic Risk						
COPC	Permeability Constant cm/hr	On-site Worker		Construction Worker		Industrial / Commercial Worker
		LADD	ELCR	LADD	ELCR	
Heptachlor	1.10E-02	7.61E-10	3.43E-09	3.04E-11	1.37E-10	7.61E-10 3.43E-09

Noncarcinogenic Risk						
COPC	Permeability Constant cm/hr	On-site Worker		Construction Worker		Industrial / Commercial Worker
		ADD	HQ	ADD	HQ	
Barium	1.00E-03	2.31E-07	3.30E-06	2.11E-08	3.01E-05	2.31E-07 3.30E-06
Manganese	1.00E-03	1.80E-06	3.92E-05	1.64E-05	3.57E-04	1.80E-06 3.92E-05

Summary				
ELCR for this pathway= HI for this pathway=		On-site Worker		Industrial / Commercial Worker
		3.43E-09 4.25E-05	1.37E-10 3.88E-04	
				3.43E-09 4.25E-05

Notes:
ELCR: Excess lifetime cancer risks
HI: Hazard Index
COPC: Contaminants of potential concern
LAOD: Lifetime average daily dose
ADD: Average daily dose
HQ: Hazard quotient

Table A-9.
DERMAL EXPOSURE EVALUATION FOR GROUNDWATER
FOR LAKE CALUMET CLUSTER SITE: ALBURN

COPC	Permeability Constant cm/hr	Carcinogenic Risk			
		On-site Worker		Industrial / Commercial Worker	
		LADD	ELCR	LADD	ELCR
Arsenic	1.00E-03	2.81E-08	4.22E-08	1.13E-09	1.69E-09
Beryllium	1.00E-03	1.45E-09	0.00E+00	5.81E-11	0.00E+00
Benzene	2.10E-02	1.16E-05	8.39E-07	4.65E-07	2.56E-08
Bis(2-Chloroethyl) Ether	2.10E-03	1.26E-07	1.39E-07	5.04E-09	5.54E-09
Methylene chloride	4.50E-03	1.76E-07	1.32E-09	7.06E-09	5.29E-11
N-Nitrosodiphenylamine	2.00E-02	2.77E-08	1.36E-10	1.11E-09	5.42E-12
				2.77E-08	1.36E-10

COPC	Permeability Constant cm/hr	Noncarcinogenic Risk			
		On-site Worker		Industrial / Commercial Worker	
		ADD	HQ	ADD	HQ
Antimony	1.00E-03	4.26E-09	1.07E-05	3.89E-08	9.72E-05
Arsenic	1.00E-03	7.88E-08	2.63E-04	7.19E-07	2.40E-03
Barium	1.00E-03	3.00E-06	4.29E-05	2.74E-05	3.91E-04
Beryllium	1.00E-03	4.07E-09	2.03E-06	3.71E-08	1.86E-05
Cadmium	1.00E-03	1.41E-08	2.83E-05	1.29E-07	2.58E-04
Chromium	1.00E-03	2.27E-07	1.52E-07	2.07E-06	1.39E-06
Manganese	1.00E-03	2.63E-06	5.71E-05	2.40E-05	6.21E-04
Mercury	1.00E-03	2.32E-09		2.12E-08	
Nickel	1.00E-03	1.39E-07	6.97E-06	1.27E-06	6.36E-05
Thallium	1.00E-03	1.68E-09	2.10E-05	1.53E-08	1.92E-04
Vanadium	1.00E-03	1.84E-07	2.34E-05	1.50E-06	2.14E-04
Zinc	1.00E-03	4.48E-06	1.49E-05	4.09E-05	1.36E-04
Bis(2-ethylhexyl)phthalate	3.30E-02	1.68E-06	8.42E-05	1.54E-05	7.68E-04
Chlorobenzene	4.10E-02	4.50E-06	2.25E-04	4.11E-05	2.05E-03
2,4-Dimethylphenol	1.50E-02	3.10E-06	1.55E-04	2.83E-05	1.41E-03
Ethylbenzene	7.40E-02	2.77E-04	2.77E-03	2.53E-03	2.53E-02
Methylene chloride	4.50E-03	4.94E-07	8.23E-06	4.51E-06	7.51E-05
Naphthalene	6.90E-02	1.87E-05	9.36E-04	1.71E-04	8.54E-03
Toluene	4.50E-02	1.10E-03	5.52E-03	1.01E-02	5.04E-02
Xylenes	8.00E-02	9.30E-04	4.65E-04	8.49E-03	4.24E-03

Summary			
On-site Worker		Industrial / Commercial Worker	
ELCR for this pathway=	8.22E-07	3.29E-08	8.22E-07
HI for this pathway=	1.06E-02	9.71E-02	1.06E-02

Notes:

ELCR: Excess lifetime cancer risks
 HI: Hazard Index
 COPC: Contaminants of potential concern
 LADD: Lifetime average daily dose
 Average daily dose
 hazard quotient

Table A-10.
PARTICULATE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER
SITE: ALBURN

Carcinogenic Risk					
$LADD = EPC \times ER \times IR \times EF \times ED / (BW \times AT_c)$					
EPC = exposure point concentration in air (ug/m3) = EPC x PIF					
ER = exposure rate (hrs/day)					
IR = inhalation rate (m3/hour)					
EF = exposure frequency (days/year)					
ED = exposure duration (years)					
BW = body weight (kg)					
AT _c = averaging time for carcinogens (days)					
PIF = Particulate Inhalation factor (kg/m3)					
ELCR = LADD x SFI					
SFI = inhalation cancer slope factor (kg-day/mg)					
LADD = lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Workers	Mower	Landscape Worker
IR (m3/hour)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	5	8	8	8	8
EF (days/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
At _c (days)	25550	25550	25550	25550	25550
Particulate Inhalation factor	8.00E-10	8.00E-09	8.00E-10	8.00E-09	8.00E-10
Conversion from ug to mg	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Noncarcinogenic Risk					
$ADD = EPC \times ER \times IR \times EF \times ED / (BW \times AT_n)$					
EPC = exposure point concentration in air (ug/m3)					
ER = exposure rate (hrs/day)					
IR = inhalation rate (m3/hr)					
EF = exposure frequency (days/year)					
ED = exposure duration (years)					
BW = body weight (kg)					
AT _n = averaging time for noncarcinogens (days)					
$HQ = ADD / RfDI$					
ADD = average daily dose (mg/kg-day)					
RfDI = inhalation reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Workers	Mower	Landscape Worker
IR (m3/hour)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	5	8	8	8	8
EF (days/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
At _n (days)	9125	9125	9125	9125	40
Particulate Inhalation factor	8.00E-10	8.00E-09	8.00E-10	8.00E-10	8.00E-10

Table A-11.
PARTICULATE EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: ALBURN

Carcinogenic Risk																				
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker											
	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR										
Arsenic	4.98E-11	0.00E+00	4.87E-11	0.00E+00	3.98E-10	0.00E+00	2.46E-10	0.00E+00	3.19E-11	0.00E+00										
Beryllium	4.78E-12	0.00E+00	4.67E-12	0.00E+00	3.83E-11	0.00E+00	2.36E-11	0.00E+00	3.06E-12	0.00E+00										
Benzene	2.55E-10	7.40E-12	2.50E-10	7.24E-12	2.04E-09	5.92E-11	1.26E-09	3.66E-11	1.63E-10	4.74E-12										
Benz(a)anthracene	1.57E-11	4.85E-12	1.50E-11	4.75E-12	1.25E-10	3.88E-11	7.75E-11	2.40E-11	1.00E-11	3.11E-12										
Benz(b)fluoranthene	1.80E-11	5.57E-12	1.76E-11	5.44E-12	1.44E-10	4.45E-11	8.88E-11	2.75E-11	1.15E-11	3.56E-12										
Benz(a)pyrene	1.36E-11	4.22E-11	1.33E-11	4.13E-11	1.09E-10	3.38E-10	6.74E-11	2.09E-10	8.72E-12	2.70E-11										
Dibenz(a,h)anthracene	4.65E-12	1.44E-11	4.54E-12	1.41E-11	3.72E-11	1.15E-10	2.30E-11	7.13E-11	2.97E-12	9.22E-12										
Indeno(1,2,3-cd)pyrene	9.01E-12	2.79E-12	8.81E-12	2.73E-12	7.21E-11	2.24E-11	4.46E-11	1.38E-11	5.77E-12	1.79E-12										
Bis(2-Chloroethyl) Ether	2.71E-12	3.14E-12	2.65E-12	3.07E-12	2.17E-11	2.52E-11	1.34E-11	1.55E-11	1.73E-12	2.01E-12										
Methylene chloride	1.68E-10	2.78E-13	1.65E-10	2.72E-13	1.35E-09	2.22E-12	8.33E-10	1.37E-12	1.08E-10	1.78E-13										
Tetrachloroethene	1.75E-10	3.49E-13	1.71E-10	3.41E-13	1.40E-09	2.79E-12	8.63E-10	1.73E-12	1.12E-10	2.23E-13										
Trichloroethene	2.57E-10	1.54E-12	2.51E-10	1.51E-12	2.05E-09	1.29E-11	1.27E-09	7.62E-12	1.64E-10	9.86E-13										
Vinyl Chloride	1.56E-10	2.50E-12	1.53E-10	2.44E-12	1.25E-09	2.00E-11	7.73E-10	1.24E-11	1.00E-10	1.60E-12										
Total PCBs	5.96E-12	1.19E-11	5.83E-12	1.17E-11	4.77E-11	8.54E-11	2.95E-11	5.90E-11	3.81E-12	7.63E-12										
Noncarcinogenic Risk																				
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker											
	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ										
Antimony	1.36E-10		1.33E-10		1.09E-09		6.75E-11		1.99E-08											
Arsenic	1.39E-10		1.36E-10		1.12E-09		6.89E-11		2.03E-08											
Barium	3.31E-09	2.31E-05	3.23E-09	2.26E-05	2.84E-08	1.85E-04	1.63E-09	1.14E-05	4.83E-07	3.37E-03										
Beryllium	1.34E-11	2.34E-06	1.31E-11	2.28E-06	1.07E-10	1.88E-05	8.62E-12	1.16E-08	1.95E-09	3.42E-04										
Cadmium	6.29E-11		6.15E-11		5.04E-10		3.11E-11		9.19E-09											
Chromium	2.25E-09		2.20E-09		1.80E-08		1.11E-09		3.28E-07											
Manganese	3.38E-08	2.35E-03	3.28E-08	2.30E-03	2.89E-07	1.88E-02	1.68E-08	1.16E-03	4.90E-06	3.43E-01										
Carbon disulfide	7.13E-10	3.57E-09	6.97E-10	3.49E-09	5.71E-09	2.85E-08	3.53E-10	1.78E-09	1.04E-07	5.21E-07										
Chlorobenzene	3.57E-10	6.26E-08	3.49E-10	6.12E-08	2.86E-09	5.01E-07	1.77E-10	3.10E-08	5.22E-08	9.14E-06										
Ethylbenzene	4.07E-08	1.42E-07	3.98E-08	1.39E-07	3.25E-07	1.14E-06	2.01E-08	7.03E-08	5.94E-06	2.08E-05										
Heptachlor	3.42E-14		3.34E-14		2.73E-13		1.69E-14		4.99E-12											
Methylene chloride	4.71E-10	5.50E-10	4.61E-10	5.38E-10	3.77E-09	4.40E-09	2.33E-10	2.72E-10	8.88E-08	6.03E-08										
Tetrachloroethene	4.89E-10		4.78E-10		3.91E-09		2.42E-10		7.14E-08											
Trichloroethene	7.19E-10		7.03E-10		5.75E-09		3.58E-10		1.05E-07											
Toluene	1.44E-08	1.26E-07	1.41E-08	1.23E-07	1.15E-07	1.01E-06	7.11E-09	6.24E-08	2.10E-06	1.84E-05										
Vinyl Chloride	4.37E-10	1.51E-08	4.28E-10	1.47E-08	3.50E-09	1.21E-07	2.16E-10	7.46E-09	6.39E-08	2.20E-06										
Xylenes	2.15E-07		2.10E-07		1.72E-06		1.06E-07		3.14E-05											
Summary																				
On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker												
ELCR for this pathway=		8.32E-11		6.81E-10		4.21E-10		5.44E-11												
HI for this pathway=		2.32E-03		1.90E-02		1.17E-03		3.47E-01												
Notes:																				
ELCR: Excess lifetime cancer risks																				
HI: Hazard Index																				
COPC: Contaminants of potential concern																				
LADD: Lifetime average daily dose																				
ADD: Average daily dose																				
HQ: d quotient																				

Table A-12.
GROUNDWATER VOLATILE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET
CLUSTER SITE: ALBURN

Carcinogenic Risk

$$LADD = (EPC \times IR \times EF \times ED) / (BW \times ATc \times CF)$$

EPC = exposure point concentration in air (g/m³)

IR = inhalation rate (m³/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

ATc = averaging time for carcinogens (day)

CF = Conversion Factor

$$ELCR = LADD \times SFi$$

SFi = Inhalation Slope Factor (kg-day/mg)

LADD = lifetime average daily dose (mg/kg-day)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF (days/year)	5	5	5		
ATc (days)	25550	25550	25550		
IR (m ³ /day)	20	20	20	20	20
BW (kg)	70	70	70	70	70
CF (mg-g)	0.001	0.001	0.001	0.001	0.001

Noncarcinogenic Risk

$$ADD = EPC \times IR \times EF \times ED / (BW \times ATn)$$

EPC = exposure point concentration in air (g/m³)

IR = inhalation rate (m³/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

ATn = average time for noncarcinogens (years)

Conversion Factor = 1000

$$HQ = ADD / Rfd$$

ADD = average daily dose

Rfd = Volatile Inhalation Reference Dose (mg/kg-day)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF (days/year)	5	5	5		
ATn (days)	9125	40	9125		
IR (m ³ /day)	20	20	20	20	20
BW (kg)	70	70	70	70	70
CF	0.001	0.001	0.001	0.001	0.001

Table A-13.

**GROUNDWATER VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE:
ALBURN**

Carcinogenic Risk									
COPC	Henry's Law Constant	On-site Worker		Construction Worker		Commercial Worker		Industrial / Commercial Worker	
		LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR
Benzene	2.28E-01	5.49E-08	1.59E-09	2.19E-09	6.36E-11	5.49E-08	1.59E-09	5.49E-08	1.59E-09
Methylene chloride	8.98E-02	1.83E-09	3.02E-12	7.31E-11	1.21E-13	1.83E-09	3.02E-12	1.83E-09	3.02E-12
Noncarcinogenic Risk									
COPC	Henry's Law Constant	On-site Worker		Construction Worker		Commercial Worker		Industrial / Commercial Worker	
		ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ
Chlorobenzene	1.52E-01	6.44E-09	1.13E-06	5.88E-08	1.03E-05	6.44E-09	1.13E-06	6.44E-09	1.13E-06
Ethylbenzene	3.23E-01	4.19E-07	1.46E-06	3.82E-06	1.34E-05	4.19E-07	1.46E-06	4.19E-07	1.46E-06
Methylene chloride	8.98E-02	5.12E-09	5.97E-09	4.67E-08	5.45E-08	5.12E-09	5.97E-09	5.12E-09	5.97E-09
Toluene	2.72E-01	2.55E-06	2.23E-05	2.32E-05	2.04E-04	2.55E-06	2.23E-05	2.55E-06	2.23E-05
Xylenes	2.15E-01	1.11E-06		1.01E-05		1.11E-06		1.11E-06	
Summary									
ELCR for this pathway=		1.59E-09		6.38E-11		1.59E-09		1.59E-09	
HI for this pathway=		2.49E-05		2.28E-04		2.49E-05		2.49E-05	

Notes:

ELCR: Excess lifetime cancer risks

HI: Hazard index

COPC: Contaminants of potential concern

LADD: Lifetime average daily dose

ADD: Average daily dose

HQ: Hazard quotient

Table A-14.
SOIL VOLATILE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE: ALBURN

Carcinogenic Risk

$$LADD = (EPC \times ER \times IR \times EF \times ED) / (VF \times BW \times ATc)$$

EPC = Exposure Point Concentration (ug/kg)
ER = Exposure Rate (hours/day)
IR = Inhalation Rate (m³/hr)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
VF = Volatilization Factor (m³/kg)
BW = Body Weight (kg)
ATc = Averaging Time for Carcinogens (day)

$$VF = Q/C \times (((3.14 \times D \times T)^{0.5} / (2 \times R \times D)) \times CF$$

Q/C = Inverse of the mean concentration at the center of a square source = (g/m²-s)/(kg/m³)
D = Apparent Diffusivity (cm²/s)
T = Exposure Interval (s)
R = Dry Soil Bulk Density = g/cm³
Cf = Conversion factor (10 E-4 m²/cm²)

$$D = (O_a^{2.25} \times D_i \times H') + (O_w^{2.25} \times D_w / n^2) \times (1 / ((p_o \times K_d) + O_w + (O_a \times H'))$$

O_a = Air-Filled Soil Porosity 0.13 For Subsurface Soil
D_i = Diffusivity in Air (cm²/s) Chemical Specific
H' = Henry's Law Constant Chemical Specific
O_w = Water-Filled Soil Porosity 0.3 For Subsurface Soil
D_w = Diffusivity in Water (cm²/s) Chemical Specific
n = Total Soil Porosity 0.43
p_o = Dry Soil Bulk Density (g/cm³) 1.5
K_d = Soil Water Partition Coeff = K_{oc} x f_{oc}
K_{oc} Chemical Specific
f_{oc} 0.002

$$ELCR = LADD \times URF$$

URF = Inhalation Unit Risk (m³/ug)
LADD = lifetime average daily dose (ug/m³)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF (days/year)	50	30	250	10	20
ATn (days)	9125	40	9125	9125	40
ATc (days)	25550	25550	25550	25550	25550
IR (m ³ /hr)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	1	8	8	8	4
BW (kg)	70	70	70	70	70

Noncarcinogenic Risk

$$ADD = EPC \times IR \times ER \times EF \times ED / (ATn \times VF \times BW)$$

EPC = exposure point concentration (ug/kg)
ER = exposure rate (hours/day)
IR = inhalation rate (m³/hr)
EF = exposure frequency (days/year)
ED = exposure duration (years)
ATn = average time for noncarcinogens (years)
VF = Volatilization Factor (m³/kg)
Conversion Factor = 1000

$$HQ = ADD / Rfc$$

ADD = average daily dose (m³/ug)
Rfc = Volatile Inhalation Reference Dose (ug/m³)

Table A-15.
SOIL VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: ALBURN

	Q/C	DI	H'	DW	KOC	Kd	D	T	Ro	VF	T _{Construction}	VF _{Construction}
	g/sq.m/kg/cu.m	(sq.cm/sec)		(sq.cm/sec)	cm ³ /g	cu.cm/g	(sq.cm/sec)	Sec	g/cu.cm	cu.m/kg	Sec	cu.m/kg
COPC												
Tetrachloroethene	85.81	7.20E-02	7.54E-01	8.20E-06	1.55E+02	3.10E-01	3.82E-04	7.90E+08	1.50E+00	7.29E+03	3.60E+06	4.92E+02
Trichloroethene	85.81	7.90E-02	4.22E-01	9.10E-06	1.66E+02	3.32E-01	2.38E-04	7.90E+08	1.50E+00	9.24E+03	3.60E+06	6.23E+02
Vinyl Chloride	85.81	1.06E-01	1.11E+00	1.23E-06	1.86E+01	3.72E-02	1.43E-03	7.90E+08	1.50E+00	3.77E+03	3.60E+06	2.55E+02
Benzene	85.81	8.80E-02	2.28E-01	9.80E-06	5.89E+01	1.18E-01	2.42E-04	7.90E+08	1.50E+00	9.16E+03	3.60E+06	6.18E+02
Methylene chloride	85.81	1.01E-01	8.98E-02	1.17E-05	1.17E+01	2.34E-02	1.62E-04	7.90E+08	1.50E+00	1.12E+04	3.60E+06	7.56E+02
Carbon disulfide	85.81	1.04E-01	1.24E+00	1.00E-05	4.57E+01	9.14E-02	1.31E-03	7.90E+08	1.50E+00	3.94E+03	3.60E+06	2.66E+02
Chlorobenzene	85.81	7.30E-02	1.52E-01	8.70E-06	2.19E+02	4.38E-01	6.97E-05	7.90E+08	1.50E+00	1.71E+04	3.60E+06	1.15E+03
Ethylbenzene	85.81	7.50E-02	3.23E-01	7.80E-06	3.63E+02	7.26E-01	1.03E-04	7.90E+08	1.50E+00	1.40E+04	3.60E+06	9.47E+02
Toluene	85.81	8.70E-02	2.72E-01	8.60E-06	1.82E+02	3.64E-01	1.84E-04	7.90E+08	1.50E+00	1.11E+04	3.60E+06	7.52E+02
Xylenes	85.81	7.14E-02	2.15E-01	9.34E-06	3.74E+02	7.48E-01	6.48E-05	7.90E+08	1.50E+00	1.77E+04	3.60E+06	1.19E+03

Carcinogenic Risk											
	On-site Worker			Construction Worker			Industrial / Commercial Worker			Landscapes Worker	
	LADD	ELCR	HQ	LADD	ELCR	HQ	LADD	ELCR	HQ	LADD	ELCR
COPC											
Benzene	7.0E-03	5.8E-08	5.0E-02	4.2E-07	2.3E-06	2.3E-06	2.8E-01	2.3E-06	1.7E-02	1.4E-07	9.2E-08
Methylene chloride	3.8E-03	1.8E-09	2.7E-02	1.3E-06	1.5E-01	7.1E-08	9.3E-03	4.4E-09	6.0E-03	2.8E-09	2.8E-09
Tetrachloroethene	6.0E-03	3.4E-09	8.0E-02	4.6E-06	4.4E-01	2.5E-07	2.7E-02	1.6E-08	1.8E-02	1.0E-08	1.0E-08
Trichloroethene	7.0E-03	1.2E-06	2.7E-02	4.7E-08	1.5E-01	2.6E-07	9.3E-03	1.6E-08	6.0E-03	1.0E-08	1.0E-08
Vinyl Chloride	1.0E-02	4.7E-08	2.0E-02	9.2E-08	1.1E-01	5.1E-07	6.9E-03	3.1E-08	4.5E-03	2.0E-08	2.0E-08

Noncarcinogenic Risk											
	On-site Worker			Construction Worker			Industrial / Commercial Worker			Landscapes Worker	
	ADD	HQ	ADD	ADD	HQ	ADD	ADD	HQ	ADD	ADD	HQ
COPC											
Tetrachloroethene	1.7E-02		2.8E+01			6.7E-01			4.1E-02	6.1E+00	
Trichloroethene	1.9E-02		3.2E+01			7.8E-01			4.8E-02	7.1E+00	
Vinyl Chloride	2.9E-02	2.9E-04	4.8E+01	4.7E-01	1.1E-02	1.2E+00	1.1E-02	7.1E-04	7.2E-02	1.1E+01	1.0E-01
Carbon disulfide	4.5E-02	6.5E-05	7.5E+01	1.1E-01	2.6E-03	1.8E+00	1.1E-01	1.6E-04	1.3E-01	1.7E+01	2.4E-02
Chlorobenzene	5.2E-03	2.6E-04	8.6E+00	4.3E-01	1.0E-02	2.1E-01	1.0E-02	6.5E-04	1.9E+00	1.9E+00	9.6E-02
Ethylbenzene	8.4E-03	2.8E-06	1.2E+03	4.0E-01	9.7E-03	2.9E+01	9.7E-03	6.0E-04	2.6E+02	2.6E+02	8.8E-02
Methylene chloride	7.6E-07		1.1E+01			2.8E-01			1.7E-02	2.5E+00	
Toluene	3.2E-01	8.1E-04	5.3E+02	1.3E+00	3.2E-02	1.3E+01	3.2E-02	2.0E-03	1.2E+02	1.2E+02	3.0E-01
Xylenes	3.0E+00		5.0E+03			1.2E+02			7.5E+00	1.1E+03	

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscapes Worker
ELCR for this pathway	1.22E-07	6.16E-07	3.40E-06	2.10E-07	1.36E-07
HI for this pathway	1.07E-03	2.17E+00	5.25E-02	3.25E-03	4.79E-01

SOIL VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: ALBURN

Table A-15.

Notes:

- ELCR: Excess lifetime cancer risks
- HI: Hazard Index
- COPC: Contaminants of potential concern
- LADD: Lifetime average daily dose
- ADD: Average daily dose
- HQ: Hazard quotient

Bold shaded area indicated ELCR or HI exceedances for the receptor

Table A-16.
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT FOR LAKE CALUMET CLUSTER SITE: ALBURN

Summary of Human Risk Assessment for Soil, Sediment, Surface water and Groundwater

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	6.E-06	2.E-06	3.E-05	1.E-05	2.E-06
Total HI	3.E-02	3.E+00	2.E-01	4.E-02	8.E-01

Summary of Human Risk Assessment for Soil, Sediment and Surface water

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	5.E-06	2.E-06	2.E-05	1.E-05	2.E-06
Total HI	2.E-02	3.E+00	2.E-01	4.E-02	8.E-01

Summary of Human Risk Assessment for Soil

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	5.E-06	2.E-06	2.E-05	1.E-05	2.E-06
Total HI	2.E-02	3.E+00	2.E-01	4.E-02	8.E-01

Table A-16.
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT FOR LAKE CALUMET CLUSTER SITE: ALBURN

Summary of Human Risk Assessment for Groundwater

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	8.E-07	3.E-08	8.E-07		
Total HI	1.E-02	1.E-01	1.E-02		

Summary of Human Risk Assessment for Surface water

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	3.E-09	1.E-10	3.E-09		
Total HI	4.E-05	4.E-04	4.E-05		

Summary of Human Risk Assessment for Sediment

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	2.E-07	9.E-09	2.E-07		
Total HI	1.E-03	1.E-02	1.E-03		

Notes:

ELCR: Excess lifetime cancer risks

HI: Hazard index

Bold shaded area indicated ELCR or HI exceedances for the receptor

Table A-17.
EXCEEDANCES SUMMARY OF CHEMICAL OF POTENTIAL CONCERN FOR LAKE CALUMET
CLUSTER SITE: ALBURN

COPCs of Carcinogenic Risk In Soil

COPC	Receptors
Arsenic	Industrial/Commercial Worker, Mower
Benzene	Industrial/Commercial Worker
Benzo(a)pyrene	Industrial/Commercial Worker, Mower
Total PCBs	Industrial/Commercial Worker
Vinyl Chloride	Industrial/Commercial Worker, Mower

COPCs of Noncarcinogenic Risk In Soil

COPC	Receptors
Toluene	Construction Worker

Notes:
 ELCR: Excess lifetime cancer risks
 HI: Hazard index
 Carcinogenic exceedances: ELCR is greater than 1.00E-06
 Noncarcinogenic exceedances: HI is greater than 1.00E+00

Table B-1.
TOXICITY FACTORS FOR CHEMICALS OF POTENTIAL CONCERN FOR LAKE CALUMET CLUSTER SITE: USDRUM

Carcinogenic Risk									
COPC	Ingestion Slope Factor (kg-day/mg)	EPC for Soil (ug/kg)	EPC for Sediment (ug/kg)	EPC for SW (ug/L)	EPC for GW (ug/L)	EPC for GW In air (g/m)	Particulate Inhalation Slope Factor (kg-day/mg)	Dermal Slope Factor (kg-day/mg)	Volatile (URF) Inhalation Risk Factor (m ³ /ug)
Arsenic	1.50E+00	1.70E+04			5.20E+01			1.50E+00	0.00E+00
Beryllium		8.18E+02			5.00E+00			0.00E+00	0.00E+00
Benzene	5.50E-02	2.41E+03			7.20E+01	5.16E-09	2.90E-02	5.50E-02	8.29E-08
Benzof(a)anthracene	7.30E-01	1.15E+04			2.00E+00		3.10E-01	7.30E-01	8.86E-05
Benzof(b)fluoranthene	7.30E-01	1.39E+04			2.00E+00		3.10E-01	7.30E-01	8.86E-05
Benzof(k)fluoranthene	7.30E-02				2.00E+00		3.10E-02	7.30E-02	8.86E-06
Benzof(a)pyrene	7.30E+00	1.22E+04			2.00E+00		3.10E+00	7.30E+00	8.86E-04
Chloroform	6.10E-03	3.49E+03			2.00E+00		8.10E-02	8.10E-02	2.31E-05
Chrysene	7.30E-03				2.00E+00		3.10E-03	7.30E-03	8.86E-07
Dibenz(a,h)anthracene	7.30E+00	8.41E+03					3.10E+00	7.30E+00	8.86E-04
1,2-Dichloroethane	9.10E-02	5.26E+03						9.10E-02	0.00E+00
4,4'-DDD	2.40E-01			3.00E-02				2.40E-01	0.00E+00
4,4'-DDE	3.40E-01			1.00E-02				3.40E-01	0.00E+00
Heptachlor	4.50E+00			2.00E-02			4.50E+00	4.50E+00	1.29E-03
Indeno(1,2,3-cd)pyrene	7.30E-01	1.19E+04			1.00E+00		3.10E-01	7.30E-01	8.86E-05
Tetrachloroethane	5.20E-02	5.49E+03					2.00E-03	5.20E-02	5.71E-07
Vinyl Chloride	7.20E-01	4.59E+03					1.60E-02	7.20E-01	4.57E-08
Total PCBs	2.00E+00	2.24E+04					2.00E+00	2.00E+00	

Noncarcinogenic Risk									
COPC	Ingestion Reference Dose (mg/kg-day)	EPC for Soil (ug/kg)	EPC for Sediment (ug/kg)	EPC for SW (ug/L)	EPC for GW (ug/L)	EPC for GW In air (g/m)	Inhalation Reference Dose (mg/kg-day)	Dermal Reference Dose (mg/kg-day)	Volatile Inhalation Ref. Dose (ug/m ³)
Antimony	4.00E-04	1.21E+04			1.60E+02			4.00E-04	0.00E+00
Arsenic	3.00E-04	1.70E+04			5.20E+01			3.00E-04	0.00E+00
Barium	7.00E-02			1.53E+02	2.53E+03		1.43E-04	7.00E-02	5.01E-01
Beryllium	2.00E-03	8.18E+02			5.00E+00		5.71E-08	2.00E-03	2.00E-02
Cadmium	5.00E-04				1.10E+01			5.00E-04	0.00E+00
Chromium	1.50E+00	1.48E+05			2.88E+02			1.50E+00	0.00E+00
Manganese	4.60E-02	2.11E+06		1.45E+02	8.52E+03		1.43E-05	4.60E-02	5.01E-02
Mercury				2.80E+00	2.80E+00		8.60E-05	0.00E+00	3.01E-01
Nickel	2.00E-02				1.11E+02			2.00E-02	0.00E+00
Vanadium	2.00E-02				1.92E+02			2.00E-02	0.00E+00
Bis(2-ethylhexyl)phthalate	8.00E-01	7.81E+04						8.00E-01	0.00E+00
Chlorobenzene	2.00E-02	7.95E+03					5.71E-03	2.00E-02	2.00E+01
Chloroform	1.00E-02	3.49E+03						1.00E-02	0.00E+00
Endrin	3.00E-04			2.00E-02				3.00E-04	0.00E+00
Ethylbenzene	1.00E-01	1.19E+05						1.00E-01	1.00E+03
Heptachlor	5.00E-04			2.00E-02			2.86E-01	5.00E-04	0.00E+00
Tetrachloroethane	1.00E-02	5.49E+03						1.00E-02	0.00E+00
Toluene	2.00E-01	1.90E+04					1.14E-01	2.00E-01	3.99E+02
Vinyl Chloride	3.00E-03	4.59E+03					2.90E-02	3.00E-03	1.02E+02
Xylenes	2.00E+00	9.50E+05						2.00E+00	0.00E+00

Note:
COPC: Contaminants of potential concern
EPC: Exposure point concentration

Table B-2.
SOIL INGESTION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
USDNUM

Carcinogenic Risk					
$LADD = EPC \times FI \times IRS \times EF \times ED \times CF / (BW \times ATc)$					
EPC=exposure point concentration (ug/kg)					
FI=fraction ingested from contaminated source					
IRS=soil ingestion rate (mg/day)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10-9 kg/ug					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
$ELCR = LADD \times SFo$					
SFo=oral cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
IRS (mg/day)	50	480	50	480	50
FI	0.5	1	0.5	1	0.5
EF (day/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
Atc (days)	25550	25550	25550	25550	25550
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09
Noncarcinogenic Risk					
$ADD = EPC \times FI \times IRS \times EF \times ED \times CF / (BW \times ATn)$					
EPC=exposure point concentration (ug/kg)					
FI=fraction ingested from contaminated source					
IRS=soil ingestion rate (mg/day)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
BW=body weight (kg)					
ATn=averaging time for noncarcinogens (days)					
$HQ = ADD / RfDo$					
ADD-average daily dose (mg/kg-day)					
RfDo=ingestion reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
IRS (mg/day)	50	480	50	480	50
FI	0.5	1	0.5	1	0.5
EF (day/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
ATn (days)	9125	40	9125	9125	9125
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table B-3.

[illegible]

Table B-4.
SOIL DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
USDRUM

Carcinogenic Risk					
LADD=EPC _{soil} ×SA×AF×ABS×EF×ED×CF/(BW×ATC)					
EPC=exposure point concentration (ug/kg)					
SA=body surface area (cm ² /day)					
AF=soil adherence factor (mg/cm ²)					
ABS=dermal adsorption factor (unitless)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor (10 ⁻⁸ kg/ug)					
BW=body weight (kg)					
ATC=averaging time for carcinogens (days)					
ELCR=LADD×SFd					
SFd=dermal cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ² /day)	3300	3300	3300	3300	3300
AF (mg/cm ²)	0.2	0.2	0.2	0.2	0.2
ABS	Chemical Specific				
Inorganics	0.01	0.01	0.01	0.01	0.01
Bis(2-ethylhexyl)phthalate	0.4	0.4	0.4	0.4	0.4
Tetrachloroethene	0.03	0.03	0.03	0.03	0.03
Trichloroethene	0.03	0.03	0.03	0.03	0.03
Vinyl chloride	0.03	0.03	0.03	0.03	0.03
Others	0	0	0	0	0
EF (day/year) for Soil	50	10	20	30	250
EF (day/year) for Sediment	5			5	5
ET (hour/day)	5	8	8	8	8
ED (years)	25	25	25	1	25
BW (kg)	70	70	70	70	70
Atc (days) - for Soil	25550	25550	25550	25550	25550
Atc (days) - for Sediment	25550			25550	25550
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table B-4.
SOIL DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
USDRUM

Noncarcinogenic Risk					
$ADD = EPC \times SA \times AF \times ABS \times EF \times ED \times CF / (BW \times ATn)$ - Soil and Sediment					
EPC=exposure point concentration (ug/kg)					
SA=body surface area (cm ² /day)					
AF=soil adherence factor (mg/cm ²)					
ABS=dermal adsorption factor					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁹ kg/mg					
BW=body weight (kg)					
ATn =averaging time for noncarcinogens (days)					
HQ=ADD/RfDo					
ADD-average daily dose (mg/kg-day)					
RfDd=dermal reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ² /day)	3300	3300	3300	3300	3300
AF(mg/cm ²)	0.2	0.2	0.2	0.2	0.2
ABS	Chemical Specific				
Inorganics	0.01	0.01	0.01	0.01	0.01
Bis(2-ethylhexyl)phthalate	0.4	0.4	0.4	0.4	0.4
Tetrachloroethene	0.03	0.03	0.03	0.03	0.03
Trichloroethene	0.03	0.03	0.03	0.03	0.03
Vinyl chloride	0.03	0.03	0.03	0.03	0.03
Others	0	0	0	0	0
EF (day/year) for Soil	50	10	20	30	250
EF (day/year) for Sediment	5			5	5
ET (hour/day)	5	8	8	8	8
ED (years)	25	25	25	1	25
BW (kg)	70	70	70	70	70
Atn (days) - for Soil	9125	9125	9125	9125	9125
Atn (days) - for Sediment	9125			40	9125
Conversion Factor kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table B-5.
WATER DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
USDRUM

Carcinogenic Risk					
$LADD = EPC \times SA \times PC \times ET \times EF \times ED \times CF / (BW \times ATc)$					
EPC=exposure point concentration (ug/L)					
SA = Skin surface area (cm ²)					
PC=Permeability Constant (cm/hr)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁶ (L-mg/cm ² -ug)					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
ELCR=LADDxSFd					
SFd=dermal cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ²)	3300	3300	3300	3300	3300
PC(cm/hr)	Chemical Specific				
Inorganic	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Benzo(a)pyrene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Benzo(a)anthracene	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01
Benzo(b)fluoranthene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Dibenzo(a,h)anthracene	2.70E+00	2.70E+00	2.70E+00	2.70E+00	2.70E+00
Indeno(1,2,3-cd)pyrene	1.90E+00	1.90E+00	1.90E+00	1.90E+00	1.90E+00
Benzo(k)fluoranthene					
Chrysene	8.10E-01	8.10E-01	8.10E-01	8.10E-01	8.10E-01
Vinyl chloride	7.30E-03	7.30E-03	7.30E-03	7.30E-03	7.30E-03
bis(2-ethylhexyl)phthalate	3.30E-02	3.30E-02	3.30E-02	3.30E-02	3.30E-02
Tetrachloroethene	4.80E-02	4.80E-02	4.80E-02	4.80E-02	4.80E-02
Trichloroethene	1.80E-02	1.80E-02	1.80E-02	1.80E-02	1.80E-02
EF (day/year) for SW & GW	5			5	5
ET (hour/day)	1	8	8	1	1
ED (years)	25			1	25
BW (kg)	70	70	70	70	70
Atc (days) - for SW & GW	25550			25550	25550
Conversion Factor (L-mg/cm ² -ug)	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06

Table B-5.
WATER DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
USDRUM

Noncarcinogenic Risk					
$ADD = EPC \times SA \times PC \times ET \times EF \times ED \times CF / (BW \times ATn)$					
EPC=exposure point concentration (ug/L)					
SA = Skin surface area (cm ²)					
PC=Permeability Constant (cm/hr)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁸ (L-mg/cm ² -ug)					
CF=conversion factor 10 ⁻⁸ (L-mg/cm ² -ug)					
BW=body weight (kg)					
ATn =averaging time for noncarcinogens (days)					
HQ=ADD/RfDo					
ADD=average daily dose (mg/kg-day)					
RfDd=dermal reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ²)	3300	3300	3300	3300	3300
PC (cm/hr)	Chemical Specific				
Inorganic	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Benzo(a)pyrene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Benzo(a)anthracene	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01
Benzo(b)fluoranthene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Dibenzo(a,h)anthracene	2.70E+00	2.70E+00	2.70E+00	2.70E+00	2.70E+00
Indeno(1,2,3-cd)pyrene	1.90E+00	1.90E+00	1.90E+00	1.90E+00	1.90E+00
Benzo(k)fluoranthene					
Chrysene	8.10E-01	8.10E-01	8.10E-01	8.10E-01	8.10E-01
Vinyl chloride	7.30E-03	7.30E-03	7.30E-03	7.30E-03	7.30E-03
bis(2-ethylhexyl)phthalate	3.30E-02	3.30E-02	3.30E-02	3.30E-02	3.30E-02
Tetrachloroethene	4.80E-02	4.80E-02	4.80E-02	4.80E-02	4.80E-02
Trichloroethene	1.80E-02	1.80E-02	1.80E-02	1.80E-02	1.80E-02
EF (day/year) for SW & GW	5			5	5
ET (hour/day)	5	8	8	8	1
ED (years)	25			1	25
BW (kg)	70	70	70	70	70
Atn (days) - for SW & GW	9125			40	9125
Conversion Factor (L-mg/cm ² -ug)	1.00E-08	1.00E-08	1.00E-08	1.00E-08	1.00E-08

Table B-6.

DERMAL EXPOSURE EVALUATION FOR SOIL FOR LAKE CALUMET CLUSTER SITE: USDRUM

Carcinogenic Risk																
COPC	Dermal Adsorp. Factors (ABS)	On-site Worker		Mower		Landscape Worker		Construction Worker		Industrial / Commercial Worker						
		LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR					
Arsenic	3.00E-02	2.35E-07	3.52E-07	4.70E-08	7.05E-08	9.39E-08	1.41E-07	5.84E-09	8.45E-09	1.17E-06	1.76E-08					
Beryllium	1.00E-02	3.77E-09	0.00E+00	7.55E-10	0.00E+00	1.51E-09	0.00E+00	9.06E-11	0.00E+00	1.89E-08	0.00E+00					
Benzene	3.00E-02	3.34E-08	1.84E-09	6.88E-09	3.67E-10	1.34E-08	7.34E-10	8.01E-10	4.41E-11	1.67E-07	9.18E-09					
1,2-Dichloroethane	3.00E-02	7.26E-08	6.61E-09	1.45E-08	1.32E-09	2.91E-08	2.64E-09	1.74E-09	1.58E-10	3.63E-07	3.30E-08					
Chloroform	1.00E-01	1.81E-07	9.83E-10	3.22E-08	1.97E-10	6.45E-08	3.93E-10	3.87E-09	2.36E-11	8.06E-07	4.91E-09					
Tetrachloroethene	3.00E-02	7.60E-08	3.95E-09	1.52E-08	7.91E-10	3.04E-08	1.58E-09	1.82E-09	9.49E-11	3.80E-07	1.98E-08					
Vinyl Chloride	3.00E-02	8.36E-08	4.58E-08	1.27E-08	9.15E-09	2.54E-08	1.83E-08	1.53E-09	1.10E-09	3.18E-07	2.29E-07					
Total PCBs	1.40E-01	1.44E-06	2.89E-06	2.89E-07	5.77E-07	5.77E-07	1.15E-06	3.46E-08	6.93E-08	7.22E-06	1.41E-05					
Noncarcinogenic Risk																
COPC	Dermal Adsorp. Factors (ABS)	On-site Worker		Mower		Landscape Worker		Construction Worker		Industrial / Commercial Worker						
		LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR					
Antimony	1.00E-02	1.58E-07	3.90E-04	3.12E-08	7.80E-05	6.24E-08	1.56E-04	3.75E-09	9.36E-06	7.80E-07	1.95E-03					
Arsenic	3.00E-02	6.58E-07	2.19E-03	1.32E-07	4.38E-04	2.63E-07	8.77E-04	1.58E-08	5.26E-05	3.29E-06	1.10E-02					
Beryllium	1.00E-02	1.06E-06	5.28E-08	2.11E-09	1.06E-08	4.23E-09	2.11E-06	2.54E-10	1.27E-07	5.28E-08	2.64E-05					
Chromium	1.00E-02	1.91E-06	1.27E-08	3.82E-07	2.54E-07	7.63E-07	5.09E-07	4.58E-08	3.05E-08	9.54E-08	6.36E-06					
Manganese	1.00E-02	2.73E-05	5.93E-04	5.46E-08	1.19E-04	1.09E-05	2.37E-04	8.55E-07	1.42E-05	1.36E-04	2.97E-03					
Bis(2-ethylhexyl)phthalate	1.00E-01	9.82E-06	1.23E-05	1.96E-06	2.48E-06	3.93E-06	4.91E-06	2.36E-07	2.95E-07	4.91E-05	6.14E-05					
Chlorobenzene	3.00E-02	3.08E-07	1.54E-05	6.16E-08	3.08E-06	1.23E-07	6.16E-06	7.39E-09	3.69E-07	1.54E-06	7.70E-05					
Chloroform	3.00E-02	1.35E-07	1.35E-05	2.71E-06	2.71E-06	5.41E-08	5.41E-06	3.25E-09	3.25E-07	6.77E-07	6.77E-05					
Ethylbenzene	3.00E-02	4.60E-06	4.60E-05	9.20E-07	9.20E-06	1.84E-06	1.84E-05	1.10E-07	1.10E-06	2.30E-05	2.30E-04					
Tetrachloroethene	3.00E-02	2.13E-07	2.13E-05	4.26E-08	4.26E-06	6.52E-08	6.52E-06	5.11E-09	5.11E-07	1.06E-06	1.06E-04					
Toluene	3.00E-02	7.35E-07	3.67E-06	1.47E-07	7.35E-07	2.94E-07	1.47E-06	1.76E-08	8.82E-08	3.67E-06	1.84E-05					
Vinyl Chloride	3.00E-02	1.78E-07	5.93E-05	3.56E-08	1.19E-05	7.12E-08	2.37E-05	4.27E-09	1.42E-06	8.90E-07	2.97E-04					
Xylenes	3.00E-02	3.88E-05	1.84E-05	7.36E-06	3.68E-06	1.47E-05	7.36E-06	6.83E-07	4.42E-07	1.84E-04	9.20E-05					
Summary																
ELCR for this pathway=		3.30E-06		6.60E-07		1.32E-06		7.92E-08		1.65E-05						
HI for this pathway=		3.37E-03		6.74E-04		1.35E-03		8.09E-05		1.69E-02						
Notes:																
ELCR: Excess lifetime cancer risks																
HI: Hazard Index																
COPC: Contaminants of potential concern																
LADD: Lifetime average daily dose																
ADD: Average daily dose																
EQ: Hazard quotient																
Bold shaded area indicated ELCR or HI exceedances for the receptor																

Table B-7.
DERMAL EXPOSURE EVALUATION FOR SURFACE WATER
FOR LAKE CALUMET CLUSTER SITE: USDRUM

		Carcinogenic Risk					
	Permeability Constant cm/hr	On-site Worker			Construction Worker		
		LADD	ELCR		LADD	ELCR	Industrial / Commercial Worker
COPC							
4,4'-DDD	2.80E-01	1.94E-09	4.65E-10		7.75E-11	1.86E-11	LADD 1.94E-09 ELCR 4.65E-10
4,4'-DDE	2.40E-01	5.54E-10	1.88E-10		2.21E-11	7.53E-12	5.54E-10 1.88E-10
Heptachlor	1.10E-02	5.07E-11	2.28E-10		2.03E-12	9.13E-12	5.07E-11 2.28E-10

		Noncarcinogenic Risk					
	Permeability Constant cm/hr	On-site Worker			Construction Worker		
		ADD	HQ		ADD	HQ	Industrial / Commercial Worker
COPC							
Barium	1.00E-03	4.84E-07	7.06E-06		7.21E-08	1.03E-04	9.88E-08 1.41E-06
Manganese	1.00E-03	4.68E-07	1.02E-05		6.84E-06	1.49E-04	9.36E-08 2.04E-06
Endrin	1.60E-02	1.03E-09	3.44E-06		1.51E-08	5.03E-05	2.07E-10 6.89E-07
Heptachlor	1.10E-02	7.10E-10	1.42E-06		1.04E-08	2.07E-05	1.42E-10 2.84E-07

		Summary			
		On-site Worker		Construction Worker	
		ELCR for this pathway=	8.82E-10	3.53E-11	8.82E-10
HI for this pathway=		2.21E-05		3.23E-04	4.42E-06

Notes:
ELCR: Excess lifetime cancer risks
HI: Hazard index
COPC: Contaminants of potential concern
LADD: Lifetime average daily dose
ADD: Average daily dose
HQ: Hazard quotient

Table B-8.
DERMAL EXPOSURE EVALUATION FOR GROUNDWATER
FOR LAKE CALUMET CLUSTER SITE: USDRUM

Carcinogenic Risk									
COPC	Permeability Constant cm/hr	On-site Worker			Construction Worker			Industrial / Commercial Worker	
		LADD	ELCR	HQ	LADD	ELCR	HQ	LADD	ELCR
Arsenic	1.00E-03	1.20E-08	1.80E-08		4.80E-10	7.20E-10		1.20E-08	1.80E-08
Beryllium	1.00E-03	1.15E-09	0.00E+00		4.61E-11	0.00E+00		1.15E-09	0.00E+00
Benzene	2.10E-02	3.49E-07	1.92E-08		1.39E-08	7.67E-10		3.49E-07	1.92E-08
Indeno(1,2,3-cd)pyrene	1.90E+00	4.38E-07	3.20E-07		1.75E-08	1.28E-08		4.38E-07	3.20E-07

Noncarcinogenic Risk									
COPC	Permeability Constant cm/hr	On-site Worker			Construction Worker			Industrial / Commercial Worker	
		ADD	HQ		ADD	HQ		ADD	HQ
Antimony	1.00E-03	5.17E-07	1.29E-03		7.54E-06	1.89E-02		1.03E-07	2.58E-04
Arsenic	1.00E-03	1.69E-07	5.60E-04		2.45E-06	8.17E-03		3.36E-08	1.12E-04
Barium	1.00E-03	8.17E-06	1.17E-04		1.19E-04	1.70E-03		1.63E-08	2.33E-05
Beryllium	1.00E-03	1.61E-08	8.07E-06		2.36E-07	1.18E-04		3.23E-09	1.61E-06
Cadmium	1.00E-03	3.55E-08	7.10E-05		5.19E-07	1.04E-03		7.10E-09	1.42E-05
Chromium	1.00E-03	9.30E-07	6.20E-07		1.38E-05	9.05E-08		1.86E-07	1.24E-07
Manganese	1.00E-03	2.75E-05	5.98E-04		4.02E-04	8.73E-03		5.50E-06	1.20E-04
Mercury	1.00E-03	9.04E-09			1.32E-07			1.81E-09	
Nickel	1.00E-03	3.58E-07	1.79E-05		5.23E-06	2.62E-04		7.17E-08	3.58E-06
Vanadium	1.00E-03	6.20E-07	3.10E-05		9.05E-06	4.53E-04		1.24E-07	6.20E-06

Summary				
On-site Worker		Construction Worker		Industrial / Commercial Worker
ELCR for this pathway=		1.43E-08		3.57E-07
HI for this pathway=		3.93E-02		5.39E-04

Notes:
 ELCR: Excess lifetime cancer risks
 HI: Hazard index
 COPC: Contaminants of potential concern
 LADD: Lifetime average daily dose
 ADD: Average daily dose
 HQ: Hazard quotient

Table B-9.
PARTICULATE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER
SITE: USDRUM

Carcinogenic Risk					
LADD=EPCa x ER x IR x EF x ED / (BW x ATc)					
EPCa=exposure point concentration in air (ug/m3) = EPC x PIF					
ER=exposure rate (hrs/day)					
IR=inhalation rate (m3/hour)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
PIF= Particulate Inhalation factor					
ELCR=LADD x SFI					
SFI=inhalation cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Workers	Mower	Landscape Worker
IR (m3/hour)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	5	8	8	8	8
EF (days/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
Atc (days)	25550	25550	25550	25550	25550
Particulate Inhalation factor	8.00E-10	8.00E-09	8.00E-10	8.00E-09	8.00E-10
Conversion from ug to mg	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Noncarcinogenic Risk					
ADD=EPCa x ER x IR x EF x ED / (BW x ATn)					
EPCa=exposure point concentration in air (ug/m3)					
ER=exposure rate (hrs/day)					
IR=inhalation rate (m3/hr)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
BW=body weight (kg)					
ATn=averaging time for noncarcinogens (days)					
HQ=ADD/RfDI					
ADD=average daily dose (mg/kg-day)					
RfDi=inhalation reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Workers	Mower	Landscape Worker
IR (m3/hour)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	5	8	8	8	8
EF (days/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
Atn (days)	9125	9125	9125	9125	40
Particulate Inhalation factor	8.00E-10	8.00E-09	8.00E-10	8.00E-10	8.00E-10

Table B-10.

PARTICULATE EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: USDRUM

COPC	Carcinogenic Risk											
	On-site Worker			Construction Worker			Industrial / Commercial Worker			Mower		
	LADD	ELCR	ELCR	LADD	ELCR	ELCR	LADD	ELCR	ELCR	LADD	ELCR	ELCR
Arsenic	5.22E-11	0.00E+00	0.00E+00	5.10E-11	0.00E+00	0.00E+00	4.18E-10	0.00E+00	0.00E+00	2.58E-10	0.00E+00	0.00E+00
Beryllium	2.52E-12	0.00E+00	0.00E+00	2.46E-12	0.00E+00	0.00E+00	2.01E-11	0.00E+00	0.00E+00	1.24E-11	0.00E+00	0.00E+00
Benzene	7.42E-12	2.15E-13	2.10E-13	7.25E-12	2.10E-13	2.10E-13	5.93E-11	1.72E-12	1.06E-12	3.67E-11	1.06E-12	1.39E-13
Benzo(a)anthracene	3.55E-11	1.10E-11	1.08E-11	3.47E-11	1.08E-11	1.08E-11	2.84E-10	8.80E-11	5.44E-11	1.76E-10	5.44E-11	7.04E-12
Benzo(b)fluoranthene	4.09E-11	1.27E-11	1.24E-11	4.00E-11	1.24E-11	1.24E-11	3.27E-10	1.01E-10	6.27E-11	2.62E-11	2.27E-11	8.11E-12
Benzo(a)pyrene	3.76E-11	1.17E-10	1.14E-10	3.68E-11	1.14E-10	1.14E-10	3.01E-10	9.33E-10	5.77E-10	2.41E-11	2.41E-11	7.47E-11
Chloroform	1.07E-11	8.70E-13	8.51E-13	1.05E-11	8.51E-13	8.51E-13	8.59E-11	6.96E-12	4.30E-12	5.31E-11	4.30E-12	5.57E-13
Dibenz(a,h)anthracene	2.89E-11	8.97E-11	8.77E-11	2.83E-11	8.77E-11	8.77E-11	2.32E-10	7.18E-10	4.44E-10	1.43E-10	1.43E-10	5.74E-11
1,2-Dichloroethane	1.61E-11	0.00E+00	0.00E+00	1.58E-11	0.00E+00	0.00E+00	1.29E-10	0.00E+00	0.00E+00	7.98E-11	0.00E+00	0.00E+00
Indeno(1,2,3-cd)pyrene	3.65E-11	1.13E-11	1.11E-11	3.57E-11	1.11E-11	1.11E-11	2.92E-10	9.05E-11	5.59E-11	1.80E-11	5.59E-11	7.24E-12
Tetrachloroethane	1.69E-11	3.38E-14	3.30E-14	1.65E-11	3.30E-14	3.30E-14	1.35E-10	2.70E-13	1.67E-13	8.36E-11	1.67E-13	2.16E-14
Vinyl Chloride	1.41E-11	2.26E-13	2.21E-13	1.38E-11	2.21E-13	2.21E-13	1.13E-10	1.81E-12	1.12E-12	6.99E-11	1.12E-12	1.45E-13
Total PCBs	6.87E-11	1.37E-10	1.34E-10	6.72E-11	1.34E-10	1.34E-10	5.50E-10	1.10E-09	6.80E-10	3.40E-10	6.80E-10	8.80E-11
Noncarcinogenic Risk												
COPC	On-site Worker			Construction Worker			Industrial / Commercial Worker			Mower		
	ADD	HQ	HQ	ADD	HQ	HQ	ADD	HQ	HQ	ADD	HQ	HQ
Antimony	1.04E-10			1.02E-10			8.32E-10			5.14E-11		
Arsenic	1.46E-10			1.43E-10			1.17E-09			7.23E-11		
Beryllium	7.04E-12	1.23E-08	1.21E-06	6.89E-12	1.21E-06	1.21E-06	5.84E-11	9.87E-06		3.48E-12	6.10E-07	
Chromium	1.27E-09			1.24E-09			1.02E-08			6.29E-10		
Manganese	1.82E-08	1.27E-03	1.24E-03	1.78E-08	1.24E-03	1.24E-03	1.46E-07	1.02E-02		9.00E-09	6.29E-04	1.88E-01
Bis(2-ethylhexyl)phthalate	6.55E-10			6.40E-10			5.24E-09			3.24E-10		
Chlorobenzene	6.84E-11	1.20E-08	1.17E-06	6.69E-11	1.17E-06	1.17E-06	5.47E-10	9.59E-08		3.38E-11	5.83E-09	1.75E-06
Chloroform	3.01E-11			2.94E-11			2.41E-10			1.49E-11		
Ethylbenzene	1.02E-09	3.58E-09	3.49E-09	9.98E-10	3.49E-09	3.49E-09	8.18E-09	2.88E-08		5.06E-10	1.77E-09	5.22E-07
Tetrachloroethene	4.73E-11			4.62E-11			3.79E-10			2.34E-11		
Toluene	1.63E-10	1.43E-09	1.40E-09	1.60E-10	1.40E-09	1.40E-09	1.31E-09	1.15E-08		8.07E-11	7.08E-10	2.09E-07
Vinyl Chloride	3.98E-11	1.36E-09	1.33E-09	3.87E-11	1.33E-09	1.33E-09	3.16E-10	1.09E-08		1.96E-11	6.75E-10	1.99E-07
Xylenes	8.18E-09			8.00E-09			6.54E-08			4.05E-09		
Summary												
ELCR for this pathway=	On-site Worker			Construction Worker			Industrial / Commercial Worker			Mower		
	2.43E-10			2.37E-10			1.94E-08			1.20E-09		
HI for this pathway=	1.27E-03			1.24E-03			1.02E-02			8.30E-04		
Notes:												
ELCR: Excess lifetime cancer risks												
HI: Hazard Index												
COPC: Contaminants of potential concern												
LADD: Lifetime average daily dose												
ADD: Average daily dose												
HQ: Hazard quotient												

Table B-11.
GROUNDWATER VOLATILE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET
CLUSTER SITE: USDRUM

Carcinogenic Risk

$$LADD = (EPC \times IR \times EF \times ED) / (BW \times ATc \times CF)$$

EPC=exposure point concentration in air (g/m³)

IR = inhalation rate (m³/day)

EF=exposure frequency (days/year)

ED=exposure duration (years)

BW = body weight (kg)

ATc=averaging time for carcinogens (day)

CF=Conversion Factor

$$ELCR = LADD \times SFI$$

SFI = Inhalation Slope Factor (kg-day/mg)

LADD=lifetime average daily dose (mg/kg-day)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF(days/year)	5	5	5		
ATc (days)	25550	25550	25550		
IR (m ³ /day)	20	20	20	20	20
BW (kg)	70	70	70	70	70
CF(mg-g)	0.001	0.001	0.001	0.001	0.001

Noncarcinogenic Risk

$$ADD = EPC \times IR \times EF \times ED / (BW \times ATn)$$

EPC=exposure point concentration in air (g/m³)

IR = Inhalation rate (m³/day)

EF=exposure frequency (days/year)

ED=exposure duration (years)

ATn=average time for noncarcinogens (years)

Conversion Factor = 1000

$$HQ = ADD / Rfd$$

ADD=average daily dose

Rfd = Volatile Inhalation Reference Dose (mg/kg-day)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF(days/year)	5	5	5		
ATn(days)	9125	40	9125		
IR (m ³ /day)	20	20	20	20	20
BW (kg)	70	70	70	70	70
CF	0.001	0.001	0.001	0.001	0.001

Table B-12.
GROUNDWATER VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE:
USDRUM

Carcinogenic Risk						
COPC	Henry's Law Constant	On-site Worker		Construction Worker		Industrial / Commercial Worker
		LADD	ELCR	LADD	ELCR	LADD ELCR
Benzene	2.28E-01	1.65E-09	4.77E-11	6.58E-11	1.91E-12	1.65E-09 4.77E-11
Noncarcinogenic Risk						
COPC	Henry's Law Constant	On-site Worker		Construction Worker		Industrial / Commercial Worker
		ADD	HQ	ADD	HQ	ADD HQ
Benzene						
Summary						
COPC	Henry's Law Constant	On-site Worker		Construction Worker		Industrial / Commercial Worker
		ADD	HQ	ADD	HQ	ADD HQ
ELCR for this pathway=		4.77E-11		1.91E-12		4.77E-11
HI for this pathway=		0.00E+00		0.00E+00		0.00E+00

Notes:
 ELCR: Excess lifetime cancer risks
 HI: Hazard Index
 COPC: Contaminants of potential concern
 LADD: Lifetime average daily dose
 ADD: Average daily dose
 HQ: Hazard quotient

Table B-13.
SOIL VOLATILE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE: USDRUM

Carcinogenic Risk

$$LADD = (EPC \times ER \times IR \times EF \times ED) / (VF \times BW \times ATc)$$

EPC = Exposure Point Concentration (ug/kg)

ER = Exposure Rate (hours/day)

IR = Inhalation Rate (m³/hr)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

VF = Volatilization Factor (m³/kg)

BW = Body Weight (kg)

ATc = Averaging Time for Carcinogens (day)

$$VF = Q/C \times (((3.14 \times D \times T)^{0.5}) / (2 \times R \times D)) \times CF$$

Q/C = Inverse of the mean concentration at the center of a square source = (g/m²-s)/(kg/m³)

D = Apparent Diffusivity (cm²/s)

T = Exposure Interval (s)

R = Dry Soil Bulk Density = g/cm³

CF = Conversion factor (10 E-4 m²/cm²)

$$D = ((O_a^{1.33} \times D_a \times H') + (O_w^{1.33} \times D_w) / n^2) \times (1 / ((\rho_b \times K_d) + O_w + (O_a \times H')))$$

O_a = Air-Filled Soil Porosity

0.13 For Subsurface Soil

D_a = Diffusivity in Air (cm²/s)

Chemical Specific

H' = Henry's Law Constant

Chemical Specific

O_w = Water-Filled Soil Porosity

0.3 For Subsurface Soil

D_w = Diffusivity in Water (cm²/s)

Chemical Specific

n = Total Soil Porosity

0.43

ρ_b = Dry Soil Bulk Density (g/cm³)

1.5

K_d = Soil Water Partition Coeff =

K_{oc} × f_{oc}

K_{oc}

Chemical Specific

f_{oc}

0.002

$$ELCR = LADD \times URF$$

URF = Inhalation Unit Risk (m³/ug)

LADD = Lifetime average daily dose (ug/m³)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF (days/year)	50	30	250	10	20
ATn (days)	9125	40	9125	9125	40
ATc (days)	25550	25550	25550	25550	25550
IR (m ³ /hr)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	1	8	8	8	4
BW (kg)	70	70	70	70	70

Noncarcinogenic Risk

$$ADD = EPC \times IR \times ER \times EF \times ED / (ATn \times VF \times BW)$$

EPC = exposure point concentration (ug/kg)

ER = exposure rate (hours/day)

IR = inhalation rate (m³/hr)

EF = exposure frequency (days/year)

ED = exposure duration (years)

ATn = average time for noncarcinogens (years)

VF = Volatilization Factor (m³/kg)

Conversion Factor = 1000

$$HQ = ADD / Rfc$$

ADD = average daily dose (m³/ug)

Rfc = Volatile Inhalation Reference Dose (ug/m³)

Table B-14.
SOIL VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: USDRUM

	Q/C	DI	H'	Dw	Koc	Kd	D	T	Ro	VF	T _{Construction}	VF _{Construction}
COPC	g/sq.m/kg/cu.m	(sq.cm/sec)		(sq.cm/sec)	cm ³ /g	cu.cm/g	(sq.cm/sec)	Sec	g/cu.cm	cu.m/kg	Sec	cu.m/kg
Benzene	8.58E+01	8.80E-02	2.28E-01	9.80E-06	5.89E-01	1.18E-01	2.42E-04	7.90E+08	1.50E+00	9.18E+03	3.60E+06	6.18E+02
1,2-Dichloroethane	8.58E+01	1.04E-01	4.01E-02	9.90E-06	1.74E-01	3.48E-02	7.34E-05	7.90E+08	1.50E+00	1.88E+04	3.80E+06	1.12E+03
Tetrachloroethane	8.58E+01	7.20E-02	7.54E-01	8.20E-06	1.55E+02	3.10E-01	3.82E-04	7.90E+08	1.50E+00	7.29E+03	3.60E+06	4.92E+02
Vinyl Chloride	8.58E+01	1.06E-01	1.11E+00	1.23E-06	1.88E-01	3.72E-02	1.43E-03	7.90E+08	1.50E+00	3.77E+03	3.60E+06	2.55E+02
Chlorobenzene	8.58E+01	7.30E-02	1.52E-01	8.70E-06	2.19E+02	4.38E-01	6.97E-05	7.90E+08	1.50E+00	1.71E+04	3.60E+06	1.15E+03
Ethylbenzene	8.58E+01	7.50E-02	3.23E-01	7.80E-06	3.63E+02	7.28E-01	1.03E-04	7.90E+08	1.50E+00	1.40E+04	3.60E+06	9.47E+02
Toluene	8.58E+01	8.70E-02	2.72E-01	8.60E-06	1.82E+02	3.84E-01	1.64E-04	7.90E+08	1.50E+00	1.11E+04	3.60E+06	7.52E+02
Xylenes	8.58E+01	7.14E-02	2.15E-01	9.34E-06	3.74E+02	7.48E-01	6.48E-05	7.90E+08	1.50E+00	1.77E+04	3.60E+06	1.19E+03

Carcinogenic Risk											
COPC	On-site Worker			Construction Worker			Industrial / Commercial Worker			Landscape Worker	
	LADD	ELCR	HQ	LADD	ELCR	HQ	LADD	ELCR	HQ	LADD	ELCR
Benzene	2.02E-04	1.88E-09	1.47E-03	1.21E-08	8.10E-03	6.71E-08	5.01E-04	4.15E-09	3.24E-04	2.68E-09	
1,2-Dichloroethane	2.43E-04	0.00E+00	1.76E-03	0.00E+00	9.71E-03	0.00E+00	8.00E-04	0.00E+00	3.88E-04	0.00E+00	
Tetrachloroethane	5.80E-04	3.31E-10	4.20E-03	2.40E-09	2.32E-02	1.33E-08	1.43E-03	8.19E-10	9.28E-04	5.30E-10	
Vinyl Chloride	9.36E-04	4.28E-09	6.78E-03	3.10E-08	3.74E-02	1.71E-07	2.31E-03	1.06E-08	1.50E-03	6.85E-09	

Noncarcinogenic Risk											
COPC	On-site Worker			Construction Worker			Industrial / Commercial Worker			Landscape Worker	
	ADD	HQ	ELCR	ADD	HQ	ELCR	ADD	HQ	ELCR	ADD	HQ
Tetrachloroethane	1.62E-03			2.68E+00			6.49E-02			5.92E-01	
Vinyl Chloride	2.82E-03	2.58E-05		4.33E+00	4.27E-02		1.05E-01	1.03E-03	6.39E-05	9.57E-01	9.43E-03
Chlorobenzene	1.00E-03	5.02E-05		1.66E+00	8.28E-02		4.01E-02	2.01E-03	1.24E-04	3.66E-01	1.83E-02
Ethylbenzene	1.82E-02	1.82E-05		3.01E+01	3.01E-02		7.29E-01	7.28E-04	4.51E-02	6.85E+00	6.84E-03
Toluene	3.66E-03	9.19E-08		6.05E+00	1.52E-02		1.47E-01	3.67E-04	9.08E-03	1.34E+00	3.35E-03
Xylenes	1.16E-01			1.91E+02			4.82E+00		2.88E-01	4.22E+01	

Carcinogenic Risk				Noncarcinogenic Risk			
COPC		Construction Worker		Industrial / Commercial Worker		Landscape Worker	
ELCR for this pathway		3.34E-08		1.84E-07		7.38E-09	
HI for this pathway=		1.71E-01		4.13E-03		3.77E-02	

Table B-14.
SOIL VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: USDRUM

Notes:
ELCR: Excess lifetime cancer risks
HI: Hazard Index
COPC: Contaminants of potential concern
LADD: Lifetime average daily dose
ADD: Average daily dose
HQ: Hazard quotient

Table B-15.
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT FOR LAKE CALUMET CLUSTER SITE: USDRUM

Summary of Human Risk Assessment for Soil, Sediment, Surface water and Groundwater

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	1.E-05	3.E-06	5.E-05	3.E-05	4.E-06
Total HI	1.E-02	9.E-01	7.E-02	3.E-02	2.E-01

Summary of Human Risk Assessment for Soil, Sediment and Surface water

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	1.E-05	3.E-06	5.E-05	3.E-05	4.E-06
Total HI	1.E-02	9.E-01	6.E-02	3.E-02	2.E-01

Summary of Human Risk Assessment for Soil

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	1.E-05	3.E-06	5.E-05	3.E-05	4.E-06
Total HI	1.E-02	9.E-01	6.E-02	3.E-02	2.E-01

Table B-15.
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT FOR LAKE CALUMET CLUSTER SITE: USDRUM

Summary of Human Risk Assessment for Groundwater

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	4.E-07	1.E-08	4.E-07		
Total HI	3.E-03	4.E-02	5.E-04		

Summary of Human Risk Assessment for Surface water

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	9.E-10	4.E-11	9.E-10		
Total HI	2.E-05	3.E-04	4.E-06		

Notes:

ELCR: Excess lifetime cancer risks

HI: Hazard Index

Bold shaded area indicated ELCR or HI exceedances for the receptor

Table B-16.
 EXCEEDANCES SUMMARY OF CHEMICAL OF POTENTIAL CONCERN
 FOR LAKE CALUMET CLUSTER SITE: USDRUM

COPCs of Carcinogenic Risk in Soil

COPC	Receptors
Arsenic	Industrial/Commercial Worker, Mower
Benzo(a)pyrene	On-site Worker, Industrial/Commercial Worker, Mower
Dibenz(a,h)anthracene	On-site Worker, Industrial/Commercial Worker, Mower
Total PCBs	On-site Worker, Industrial/Commercial Worker, Mower, Landscape worker

Notes:

ELCR: Excess lifetime cancer risks

HI: Hazard Index

Carcinogenic exceedances: ELCR is greater than 1.00E-06

Noncarcinogenic exceedances: HI is greater than 1.00E+00

Table C-1.
TOXICITY FACTORS FOR CHEMICALS OF POTENTIAL CONCERN FOR LAKE CALUMET CLUSTER SITE: UNNAMED PARCEL

COPC	Carcinogenic Risk						
	Ingestion Slope		EPC for Soil (ug/kg)	EPC for Sediment (ug/kg)	EPC for SW (ug/L)	EPC for GW (ug/L)	EPC for GW in air (g/m)
	Factor (kg-day/mg)						
Arsenic	1.50E+00		2.33E+04			7.27E+01	
Beryllium			1.22E+03				
Benzene	5.50E-02					5.20E+01	3.79E-09
Benzofuranthene	7.30E-01		4.54E+03			2.00E+00	
Benzobifuranthene	7.30E-01		5.73E+03			2.00E+00	
Benzobifuranthene	7.30E-02		3.91E+03			1.00E+00	
Benzofuranthene	7.30E+00		4.24E+03			2.00E+00	
Chrysene	7.30E-03					2.00E+00	
Dibenz(a,h)anthracene	7.30E+00		1.50E+03			0.00E+00	
1,2-Dibromo-3-Chloropropane	1.40E+00		1.49E+03				
1,2-Dichloroethane	9.10E-02		1.16E+03				
Indeno(1,2,3-cd)pyrene	7.30E-01		2.47E+03			6.00E-01	
alpha-BHC	8.30E+00		2.42E+01				
Heptachlor	4.50E+00		1.72E+01				
Methylene chloride	7.50E-03		1.11E+03				
Trichloroethene	1.10E-02		8.77E+02				
Total PCBs	2.00E+00		2.69E+03				
Noncarcinogenic Risk							
COPC	Ingestion		EPC for Soil (ug/kg)	EPC for Sediment (ug/kg)	EPC for SW (ug/L)	EPC for GW (ug/L)	EPC for GW in air (g/m)
	Reference Dose (mg/kg-day)						
Arsenic	3.00E-04		2.33E+04			7.27E+01	
Beryllium	2.00E-03		1.22E+03				
Cadmium	5.00E-04					1.48E+02	
Chromium	1.50E+00		2.05E+05			2.99E+02	
Manganese	4.80E-02		1.49E+04			2.29E+03	
Mercury						9.30E+00	
Nickel	2.00E-02					2.48E+02	
Vanadium	2.00E-02					9.77E+01	
Zinc	3.00E-01					1.02E+04	
Bis(2-ethylhexyl)phthalate	8.00E-01					4.20E+01	
Chlorobenzene	2.00E-02		5.59E+03				
1,1-Dichloroethane	1.00E-01		1.10E+03				
Ethylbenzene	1.00E-01		3.47E+03				
Heptachlor	5.00E-04		1.72E+01				
Methylene chloride	8.00E-02		1.11E+03				
Toluene	2.00E-01		7.21E+03				
Trichloroethene	1.10E-02		8.77E+02				
1,1,1-Trichloroethane	2.00E-02		7.07E+03				
Xylenes	2.00E+00		1.96E+04				
Volatilization Risk Factor							
COPC	Ingestion		EPC for Soil (ug/kg)	EPC for Sediment (ug/kg)	EPC for SW (ug/L)	EPC for GW (ug/L)	EPC for GW in air (g/m)
	Reference Dose (mg/kg-day)						
Arsenic	3.00E-04		2.33E+04			7.27E+01	
Beryllium	2.00E-03		1.22E+03				
Cadmium	5.00E-04					1.48E+02	
Chromium	1.50E+00		2.05E+05			2.99E+02	
Manganese	4.80E-02		1.49E+04			2.29E+03	
Mercury						9.30E+00	
Nickel	2.00E-02					2.48E+02	
Vanadium	2.00E-02					9.77E+01	
Zinc	3.00E-01					1.02E+04	
Bis(2-ethylhexyl)phthalate	8.00E-01					4.20E+01	
Chlorobenzene	2.00E-02		5.59E+03				
1,1-Dichloroethane	1.00E-01		1.10E+03				
Ethylbenzene	1.00E-01		3.47E+03				
Heptachlor	5.00E-04		1.72E+01				
Methylene chloride	8.00E-02		1.11E+03				
Toluene	2.00E-01		7.21E+03				
Trichloroethene	1.10E-02		8.77E+02				
1,1,1-Trichloroethane	2.00E-02		7.07E+03				
Xylenes	2.00E+00		1.96E+04				

Note:
COPC: Contaminants of potential concern
EPC: Exposure point concentration

Table C-2.
SOIL INGESTION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Carcinogenic Risk					
$LADD = EPC \times FI \times IRS \times EF \times ED \times CF / (BW \times ATc)$					
EPC=exposure point concentration (ug/kg)					
FI=fraction ingested from contaminated source					
IRS=soil ingestion rate (mg/day)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁹ kg/ug					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
$ELCR = LADD \times SFo$					
SFo=oral cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
IRS (mg/day)	50	480	50	480	50
FI	0.5	1	0.5	1	0.5
EF (day/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
Atc (days)	25550	25550	25550	25550	25550
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09
Noncarcinogenic Risk					
$ADD = EPC \times FI \times IRS \times EF \times ED \times CF / (BW \times ATn)$					
EPC=exposure point concentration (ug/kg)					
FI=fraction ingested from contaminated source					
IRS=soil ingestion rate (mg/day)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
BW=body weight (kg)					
ATn=averaging time for noncarcinogens (days)					
$HQ = ADD / RfDo$					
ADD=average daily dose (mg/kg-day)					
RfDo=injection reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
IRS (mg/day)	50	480	50	480	50
FI	0.5	1	0.5	1	0.5
EF (day/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
ATn (days)	9125	40	9125	9125	9125
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table C-3.
SOIL INGESTION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE: UNNAMED PARCEL

Cardiogenic Risk											
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker		
	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	
Arsenic	4.07E-07	6.11E-07	1.88E-07	2.82E-07	2.04E-08	3.08E-08	1.58E-06	2.35E-06	1.63E-07	2.44E-07	
Beryllium	2.12E-08	0.00E+00	9.79E-09	0.00E+00	1.06E-07	0.00E+00	8.16E-08	0.00E+00	8.50E-09	0.00E+00	
Benzo(a)anthracene	7.94E-08	5.78E-08	3.68E-08	2.67E-08	3.97E-07	2.90E-07	3.05E-07	2.23E-07	3.16E-08	2.32E-08	
Benzo(b)fluoranthene	1.00E-07	7.31E-08	4.61E-08	3.37E-08	5.01E-07	3.65E-07	3.85E-07	2.81E-07	4.01E-08	2.92E-08	
Benzo(k)fluoranthene	6.84E-08	4.99E-09	3.15E-08	2.30E-09	3.42E-07	2.50E-08	2.63E-07	1.92E-08	2.74E-08	2.00E-08	
Benzo(a)pyrene	7.40E-08	5.40E-07	3.41E-08	2.49E-07	3.70E-07	2.70E-08	2.84E-07	2.07E-08	2.96E-08	2.16E-07	
Dibenz(a,h)anthracene	2.62E-08	1.91E-07	1.21E-08	8.82E-08	1.31E-07	9.57E-07	1.01E-07	7.35E-07	1.05E-08	7.66E-08	
1,2-Dibromo-3-Chloropropane	2.60E-08	3.64E-08	1.20E-08	1.68E-08	1.30E-07	1.82E-07	9.97E-08	1.40E-07	1.04E-08	1.45E-08	
1,2-Dichloroethane	2.03E-08	1.85E-09	9.36E-09	8.92E-10	1.02E-07	9.24E-09	7.80E-08	7.10E-09	8.13E-09	7.39E-10	
Indeno(1,2,3-cd)pyrene	4.32E-08	3.15E-08	1.88E-08	1.45E-08	2.16E-07	1.58E-07	1.66E-07	1.21E-07	1.73E-08	1.26E-08	
alpha-BHC	4.23E-10	2.67E-09	1.95E-10	1.23E-09	2.12E-09	1.33E-08	1.63E-09	1.02E-08	1.69E-10	1.07E-09	
Heptachlor	3.00E-10	1.35E-09	1.38E-10	6.22E-10	1.50E-09	6.74E-09	1.15E-09	5.18E-09	1.20E-10	5.40E-10	
Methylene chloride	1.94E-08	1.48E-10	8.94E-09	6.71E-11	9.70E-08	7.28E-10	7.45E-08	5.58E-10	7.76E-09	5.82E-11	
Trichloroethene	1.53E-08	1.69E-10	7.06E-09	7.76E-11	7.66E-08	8.43E-10	5.88E-08	6.47E-10	8.13E-09	6.74E-11	
Total PCBs	4.70E-08	9.41E-08	2.17E-08	4.34E-08	2.35E-07	4.70E-07	1.81E-07	3.81E-07	1.86E-08	3.76E-08	
Noncarcinogenic Risk											
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker		
	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	
Arsenic	1.14E-06	3.80E-03	1.20E-04	4.00E-01	5.70E-06	1.90E-02	4.39E-06	1.48E-02	4.56E-07	1.52E-03	
Beryllium	5.95E-08	2.97E-05	6.25E-06	3.13E-03	2.97E-07	1.49E-04	2.28E-07	1.14E-04	2.38E-08	1.19E-05	
Chromium	1.00E-05	6.67E-08	1.05E-03	7.01E-04	5.00E-05	3.34E-05	3.84E-05	2.56E-05	4.00E-06	2.67E-06	
Manganese	7.28E-05	1.58E-03	7.65E-03	1.66E-01	3.64E-04	7.91E-03	2.79E-04	6.08E-03	2.91E-05	6.33E-04	
Chlorobenzene	2.73E-07	1.37E-05	2.87E-05	1.44E-03	1.37E-06	6.83E-05	1.05E-06	5.25E-05	1.09E-07	5.47E-08	
1,1-Dichloroethane	5.38E-08	5.38E-07	5.66E-06	5.66E-05	2.69E-07	2.69E-06	2.07E-07	2.07E-06	2.15E-08	2.15E-07	
Ethylbenzene	1.70E-07	1.70E-06	1.78E-05	1.79E-04	6.50E-07	8.50E-06	6.53E-07	6.53E-06	8.80E-08	8.80E-07	
Heptachlor	6.39E-10	1.69E-06	8.82E-08	1.76E-04	4.20E-09	8.39E-06	3.22E-09	6.45E-06	3.36E-10	6.71E-07	
Methylene chloride	5.43E-08	9.06E-07	5.71E-06	9.52E-05	2.72E-07	4.53E-06	2.09E-07	3.48E-06	2.17E-08	3.62E-07	
Toluene	3.53E-07	1.76E-06	3.71E-05	1.85E-04	1.76E-06	8.82E-06	1.35E-06	6.77E-06	1.41E-07	7.06E-07	
Trichloroethene	4.29E-08	3.90E-08	4.51E-06	4.10E-04	2.14E-07	1.95E-05	1.65E-07	1.50E-05	1.72E-08	1.56E-06	
1,1,1-Trichloroethane	3.46E-07	1.73E-05	3.84E-05	1.82E-03	1.73E-06	8.65E-05	1.33E-06	6.64E-05	1.38E-07	6.92E-06	
Xylenes	8.57E-07	4.78E-07	1.01E-04	5.03E-05	4.78E-06	2.39E-06	3.67E-06	1.84E-06	3.83E-07	1.91E-07	
Summary											
ELCR for this pathway	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker		
	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	
ELCR for this pathway	1.85E-06		7.59E-07		8.23E-06		6.92E-06		6.59E-07		
HI for this pathway	5.46E-03		5.74E-01		2.73E-02		2.10E-02		2.16E-03		
Notes:											
ELCR: Excess lifetime cancer risks											
HI: Hazard Index											
COPC: Contaminants of potential concern											
LADD: Lifetime average daily dose											
ADD: Average daily dose											
HQ: Hazard quotient											
Bold shaded area indicated ELCR or HI exceedances for the receptor											

Table C-4.
SOIL DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Carcinogenic Risk					
$LADD = EPC_{soil} \times SA \times AF \times ABS \times EF \times ED \times CF / (BW \times ATc)$					
EPC=exposure point concentration (ug/kg)					
SA=body surface area (cm ² /day)					
AF=soil adherence factor (mg/cm ²)					
ABS=dermal adsorption factor (unitless)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor (10 ⁻⁹ kg/ug)					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
$ELCR = LADD \times SFd$					
SFd=dermal cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ² /day)	3300	3300	3300	3300	3300
AF (mg/cm ²)	0.2	0.2	0.2	0.2	0.2
ABS	Chemical Specific				
Inorganics	0.01	0.01	0.01	0.01	0.01
Bis(2-ethylhexyl)phthalate	0.4	0.4	0.4	0.4	0.4
Tetrachloroethene	0.03	0.03	0.03	0.03	0.03
Trichloroethene	0.03	0.03	0.03	0.03	0.03
Vinyl chloride	0.03	0.03	0.03	0.03	0.03
Others	0	0	0	0	0
EF (day/year) for Soil	50	10	20	30	250
EF (day/year) for Sediment	5			5	5
ET (hour/day)	5	8	8	8	8
ED (years)	25	25	25	1	25
BW (kg)	70	70	70	70	70
Atc (days) - for Soil	25550	25550	25550	25550	25550
Atc (days) - for Sediment	25550			25550	25550
Conversion Factor (kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table C-4.
SOIL DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Noncarcinogenic Risk					
ADD=EPCxSAxAFxABSxEFxEDxCF/(BWxATn)-Soil and Sediment					
EPC=exposure point concentration (ug/kg)					
SA=body surface area (cm ² /day)					
AF=soil adherence factor (mg/cm ²)					
ABS=dermal adsorption factor					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁹ kg/mg					
BW=body weight (kg)					
ATn =averaging time for noncarcinogens (days)					
HQ=ADD/RfD					
ADD=average daily dose (mg/kg-day)					
RfDd=dermal reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ² /day)	3300	3300	3300	3300	3300
AF(mg/cm ²)	0.2	0.2	0.2	0.2	0.2
ABS	Chemical Specific				
Inorganics	0.01	0.01	0.01	0.01	0.01
Bis(2-ethylhexyl)phthalate	0.4	0.4	0.4	0.4	0.4
Tetrachloroethene	0.03	0.03	0.03	0.03	0.03
Trichloroethene	0.03	0.03	0.03	0.03	0.03
Vinyl chloride	0.03	0.03	0.03	0.03	0.03
Others	0	0	0	0	0
EF (day/year) for Soil	50	10	20	30	250
EF (day/year) for Sediment	5			5	5
ET (hour/day)	5	8	8	8	8
ED (years)	25	25	25	1	25
BW (kg)	70	70	70	70	70
Atn (days) - for Soil	9125	9125	9125	9125	9125
Atn (days) - for Sediment	9125			40	9125
Conversion Factor kg/ug)	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.00E-09

Table C-5.
WATER DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Carcinogenic Risk					
$LADD = EPC \times SA \times PC \times ET \times EF \times ED \times CF / (BW \times ATc)$					
EPC=exposure point concentration (ug/L)					
SA = Skin surface area (cm ²)					
PC=Permeability Constant (cm/hr)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁶ (L-mg/cm ² -ug)					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
$ELCR = LADD \times SFd$					
SFd=dermal cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ²)	3300	3300	3300	3300	3300
PC(cm/hr)	Chemical Specific				
Inorganic	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Benzo(a)pyrene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Benzo(a)anthracene	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01
Benzo(b)fluoranthene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Dibenzo(a,h)anthracene	2.70E+00	2.70E+00	2.70E+00	2.70E+00	2.70E+00
Indeno(1,2,3-cd)pyrene	1.90E+00	1.90E+00	1.90E+00	1.90E+00	1.90E+00
Benzo(k)fluoranthene					
Chrysene	8.10E-01	8.10E-01	8.10E-01	8.10E-01	8.10E-01
Vinyl chloride	7.30E-03	7.30E-03	7.30E-03	7.30E-03	7.30E-03
bis(2-ethylhexyl)phthalate	3.30E-02	3.30E-02	3.30E-02	3.30E-02	3.30E-02
Tetrachloroethene	4.80E-02	4.80E-02	4.80E-02	4.80E-02	4.80E-02
Trichloroethene	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.60E-02
EF (day/year) for SW & GW	5			5	5
ET (hour/day)	1	1	1	1	1
ED (years)	25			1	25
BW (kg)	70	70	70	70	70
Atc (days) - for SW & GW	25550			25550	25550
Conversion Factor (L-mg/cm ² -ug)	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06

Table C-5.
WATER DERMAL EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Noncarcinogenic Risk					
$ADD = EPC \times SA \times PC \times ET \times EF \times ED \times CF / (BW \times ATn)$					
EPC=exposure point concentration (ug/L)					
SA = Skin surface area (cm ²)					
PC=Permeability Constant (cm/hr)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
CF=conversion factor 10 ⁻⁶ (L-mg/cm ² -ug)					
CF=conversion factor 10 ⁻⁶ (L-mg/cm ² -ug)					
BW=body weight (kg)					
ATn=averaging time for noncarcinogens (days)					
HQ=ADD/RfD _o					
ADD=average daily dose (mg/kg-day)					
RfD _o =dermal reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Mower	Landscape Worker	Construction Worker	Industrial / Commercial Worker
SA (cm ²)	3300	3300	3300	3300	3300
PC (cm/hr)	Chemical Specific				
Inorganic	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Benzo(a)pyrene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Benzo(a)anthracene	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01
Benzo(b)fluoranthene	1.20E+00	1.20E+00	1.20E+00	1.20E+00	1.20E+00
Dibenzo(a,h)anthracene	2.70E+00	2.70E+00	2.70E+00	2.70E+00	2.70E+00
Indeno(1,2,3-cd)pyrene	1.90E+00	1.90E+00	1.90E+00	1.90E+00	1.90E+00
Benzo(k)fluoranthene					
Chrysene	8.10E-01	8.10E-01	8.10E-01	8.10E-01	8.10E-01
Vinyl chloride	7.30E-03	7.30E-03	7.30E-03	7.30E-03	7.30E-03
bis(2-ethylhexyl)phthalate	3.30E-02	3.30E-02	3.30E-02	3.30E-02	3.30E-02
Tetrachloroethene	4.80E-02	4.80E-02	4.80E-02	4.80E-02	4.80E-02
Trichloroethene	1.80E-02	1.80E-02	1.80E-02	1.80E-02	1.80E-02
EF (day/year) for SW & GW	5			5	5
ET (hour/day)	1	1	1	1	1
ED (years)	25			1	25
BW (kg)	70	70	70	70	70
Atn (days) - for SW & GW	9125			40	9125
Conversion Factor (L-mg/cm ² -ug)	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06

Table C-6.
DERMAL EXPOSURE EVALUATION FOR SOIL FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Carcinogenic Risk																
COPC	Dermal Adscorp. Factors (ABS)	On-site Worker			Mower			Landscape Worker			Construction Worker			Industrial/Commercial Worker		
		LADD	ELCR		LADD	ELCR		LADD	ELCR		LADD	ELCR		LADD	ELCR	
Arsenic	3.00E-02	3.23E-07	4.84E-07	6.45E-08	9.68E-08	1.29E-07	1.94E-07	7.74E-09	1.16E-08	1.61E-08	2.42E-08					
Beryllium	1.00E-02	5.61E-09	0.00E+00	1.12E-09	0.00E+00	2.24E-09	0.00E+00	1.35E-10	0.00E+00	2.80E-08	0.00E+00					
1,2-Dibromo-3-Chloropropane	1.00E-02	6.66E-09	9.60E-09	1.37E-09	1.92E-09	2.74E-09	3.84E-09	1.65E-09	2.30E-10	3.43E-08	4.80E-08					
1,2-Dichloroethane	1.00E-02	5.36E-09	4.88E-10	1.07E-09	9.78E-11	2.15E-09	1.95E-10	1.29E-10	1.17E-11	2.68E-08	2.44E-08					
alpha-BHC	3.00E-02	3.35E-10	2.11E-09	6.71E-11	4.22E-10	1.34E-10	8.45E-10	1.34E-10	8.45E-10	1.68E-09	1.06E-08					
Heptachlor	3.00E-02	2.37E-10	1.07E-08	4.75E-11	2.14E-10	9.50E-11	4.27E-10	5.70E-12	2.56E-11	1.19E-09	5.34E-09					
Methylene chloride	1.00E-02	5.12E-09	3.84E-11	1.02E-09	7.69E-12	2.05E-09	1.54E-11	1.23E-10	9.22E-13	2.56E-08	1.92E-10					
Trichloroethene	3.00E-02	1.21E-08	1.33E-10	2.43E-08	2.67E-11	4.85E-09	5.34E-11	2.91E-10	3.20E-12	6.07E-08	6.67E-10					
Total PCBs	3.00E-02	3.73E-08	7.45E-08	7.45E-09	1.49E-08	1.49E-08	2.98E-08	8.94E-10	1.79E-09	1.86E-07	3.73E-07					
Noncarcinogenic Risk																
COPC	Dermal Adscorp. Factors (ABS)	On-site Worker			Mower			Landscape Worker			Construction Worker			Industrial/Commercial Worker		
		LADD	ELCR		LADD	ELCR		LADD	ELCR		LADD	ELCR		LADD	ELCR	
Arsenic	3.00E-02	9.03E-07	3.01E-03	1.81E-07	8.02E-04	3.81E-07	1.20E-03	3.81E-07	1.20E-03	4.52E-06	1.51E-02					
Beryllium	1.00E-02	1.57E-08	7.85E-06	3.14E-09	1.57E-06	8.28E-09	3.14E-06	8.28E-09	3.14E-06	7.85E-08	3.93E-05					
Chromium	1.00E-02	2.64E-06	1.78E-06	5.28E-07	3.52E-07	1.06E-06	7.04E-07	1.06E-06	7.04E-07	4.23E-08	8.61E-06					
Manganese	1.00E-02	1.92E-05	4.18E-04	3.84E-06	8.35E-05	7.69E-06	1.67E-04	4.51E-07	1.00E-05	9.61E-05	2.09E-03					
Chlorobenzene	1.00E-02	7.22E-08	3.61E-06	1.44E-08	7.22E-07	2.89E-08	1.44E-06	1.73E-09	8.66E-08	3.61E-07	1.80E-05					
1,1-Dichloroethane	1.00E-02	1.42E-08	1.42E-07	2.84E-09	2.84E-08	5.88E-09	5.88E-08	3.41E-10	3.41E-09	7.11E-07	1.80E-05					
Ethylbenzene	1.00E-02	4.49E-08	4.49E-07	8.97E-09	8.97E-08	1.79E-08	1.79E-07	1.08E-09	1.08E-08	2.24E-07	2.24E-06					
Heptachlor	3.00E-02	6.65E-10	1.33E-06	1.33E-10	2.66E-07	2.66E-10	5.32E-07	1.80E-11	3.19E-08	3.32E-09	6.65E-06					
Methylene chloride	1.00E-02	1.43E-08	2.39E-07	2.87E-09	4.78E-08	5.74E-09	9.56E-08	3.44E-10	5.74E-09	7.17E-08	1.20E-06					
Toluene	1.00E-02	9.31E-08	4.66E-07	1.86E-08	9.31E-08	3.73E-08	1.86E-07	2.24E-09	1.12E-08	4.66E-07	2.33E-06					
Trichloroethene	3.00E-02	3.40E-08	3.09E-06	6.79E-09	6.18E-07	1.36E-08	1.24E-06	8.15E-10	7.41E-08	1.70E-07	1.54E-05					
1,1,1-Trichloroethane	3.00E-02	2.74E-07	1.37E-05	5.48E-08	2.74E-06	1.10E-07	5.48E-06	6.57E-09	3.29E-07	1.37E-06	6.85E-05					
Xylene	1.00E-02	2.53E-07	1.26E-07	5.05E-08	2.53E-08	1.01E-07	5.05E-08	8.06E-09	3.03E-09	1.26E-06	6.32E-07					
Summary																
ELCR for this pathway=	HI for this pathway=	On-site Worker			Mower			Landscape Worker			Construction Worker			Industrial/Commercial Worker		
		LADD	ELCR		LADD	ELCR		LADD	ELCR		LADD	ELCR		LADD	ELCR	
		5.72E-07	3.46E-03	1.14E-07	6.92E-04	2.29E-07	1.39E-03	1.37E-08	6.31E-05	2.66E-06	1.73E-02					
Notes:																
ELCR: Excess lifetime cancer risks																
HI: Hazard Index																
COPC: Contaminants of potential concern																
LADD: Lifetime average daily dose																
ADD: Average daily dose																
HQ: Hazard quotient																

Table C-7.
DERMAL EXPOSURE EVALUATION FOR GROUNDWATER
FOR LAKE CALUMET CLUSTER SITE: UNNAMED PARCEL

Carcinogenic Risk									
COPC	Permeability Constant cm/hr	On-site Worker			Construction Worker			Industrial / Commercial Worker	
		LADD	ELCR		LADD	ELCR		LADD	ELCR
Arsenic	1.00E-03	1.68E-08	2.52E-08		6.71E-10	1.01E-09		1.68E-08	2.52E-08
Benzene	2.10E-02	2.52E-07	1.39E-08		1.01E-08	5.54E-10		2.52E-07	1.39E-08
Indeno(1,2,3-cd)pyrene	1.90E+00	2.63E-07	1.92E-07		1.05E-08	7.80E-09		2.63E-07	1.92E-07

Noncarcinogenic Risk									
COPC	Permeability Constant cm/hr	On-site Worker			Construction Worker			Industrial / Commercial Worker	
		ADD	HQ		ADD	HQ		ADD	HQ
Arsenic	1.00E-03	4.69E-08	1.56E-04		4.28E-07	1.43E-03		4.69E-08	1.56E-04
Cadmium	1.00E-03	9.58E-08	1.91E-04		8.72E-07	1.74E-03		9.58E-08	1.91E-04
Chromium	1.00E-03	1.93E-07	1.29E-07		1.76E-08	1.17E-06		1.93E-07	1.29E-07
Manganese	1.00E-03	1.48E-08	3.21E-05		1.35E-05	2.93E-04		1.48E-08	3.21E-05
Mercury	1.00E-03	8.01E-09			5.48E-08			8.01E-09	
Nickel	1.00E-03	1.80E-07	8.01E-06		1.46E-06	7.31E-05		1.80E-07	8.01E-06
Vanadium	1.00E-03	8.31E-08	3.15E-06		5.76E-07	2.88E-05		8.31E-08	3.15E-06
Zinc	1.00E-03	6.59E-06	2.20E-05		6.01E-05	2.00E-04		6.59E-06	2.20E-05
Bis(2-ethylhexyl)phthalate	2.30E-02	8.24E-07	7.80E-07		5.69E-06	7.12E-06		8.24E-07	7.80E-07

Summary				
	On-site Worker	Construction Worker	Industrial / Commercial Worker	
ELCR for this pathway=	2.31E-07	9.24E-09	2.31E-07	
HI for this pathway=	4.14E-04	3.78E-03	4.14E-04	

Notes:
 ELCR: Excess lifetime cancer risks
 HI: Hazard Index
 COPC: Contaminants of potential concern
 LADD: Lifetime average daily dose
 ADD: Average daily dose
 HQ: Hazard quotient

Table C-8.
PARTICULATE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER
SITE: UNNAMED PARCEL

Carcinogenic Risk					
$LADD = EPCa \times ER \times IR \times EF \times ED / (BW \times ATc)$					
EPCa=exposure point concentration in air (ug/m3) = EPCxPIF					
ER=exposure rate (hrs/day)					
IR=inhalation rate (m3/hour)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
BW=body weight (kg)					
ATc=averaging time for carcinogens (days)					
PIF= Particulate Inhalation factor					
ELCR=LADDxSFI					
SFI=inhalation cancer slope factor (kg-day/mg)					
LADD=lifetime average daily dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Workers	Mower	Landscape Worker
IR (m3/hour)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	5	8	8	8	8
EF (days/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
Atc (days)	25550	25550	25550	25550	25550
Particulate Inhalation factor	8.00E-10	8.00E-09	8.00E-10	8.00E-09	8.00E-10
Conversion from ug to mg	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Noncarcinogenic Risk					
$ADD = EPCa \times ER \times IR \times EF \times ED / (BW \times ATn)$					
EPCa=exposure point concentration in air (ug/m3)					
ER=exposure rate (hrs/day)					
IR=inhalation rate (m3/hr)					
EF=exposure frequency (days/year)					
ED=exposure duration (years)					
BW=body weight (kg)					
ATn=averaging time for noncarcinogens (days)					
$HQ = ADD / RfDi$					
ADD=average daily dose (mg/kg-day)					
RfDi=inhalation reference dose (mg/kg-day)					
Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Workers	Mower	Landscape Worker
IR (m3/hour)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	5	8	8	8	8
EF (days/year)	50	30	250	10	20
ED (years)	25	1	25	25	25
BW (kg)	70	70	70	70	70
Atn (days)	9125	9125	9125	9125	40
Particulate Inhalation factor	8.00E-10	8.00E-09	8.00E-10	8.00E-10	8.00E-10

Table C-9.
PARTICULATE EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Carcinogenic Risk												
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker		Landscape Worker	Worker
	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR	LADD	ELCR		
Arsenic	7.17E-11	0.00E+00	7.01E-11	0.00E+00	5.74E-10	0.00E+00	3.55E-10	0.00E+00	4.59E-11	0.00E+00	4.59E-11	0.00E+00
Beryllium	3.74E-12	0.00E+00	3.65E-12	0.00E+00	2.99E-11	0.00E+00	1.85E-11	0.00E+00	2.39E-12	0.00E+00	2.39E-12	0.00E+00
Benzo(a)anthracene	1.40E-11	4.33E-12	1.37E-11	4.23E-12	1.12E-10	3.48E-11	6.91E-11	2.14E-11	8.94E-12	2.77E-12	8.94E-12	2.77E-12
Benzo(b)fluoranthene	1.76E-11	5.48E-12	1.72E-11	5.34E-12	1.41E-10	4.37E-11	8.72E-11	2.70E-11	1.13E-11	3.50E-12	1.13E-11	3.50E-12
Benzo(k)fluoranthene	1.20E-11	3.73E-13	1.18E-11	3.65E-13	9.63E-11	2.99E-12	5.95E-11	1.85E-12	7.71E-12	2.39E-13	7.71E-12	2.39E-13
Benz(a)pyrene	1.30E-11	4.04E-11	1.27E-11	3.95E-11	1.04E-10	3.23E-10	6.44E-11	2.00E-10	8.34E-12	2.58E-11	8.34E-12	2.58E-11
Dibenz(a,h)anthracene	4.62E-12	1.43E-11	4.51E-12	1.40E-11	3.69E-11	1.14E-10	2.28E-11	7.08E-11	2.85E-12	9.18E-12	2.85E-12	9.18E-12
1,2-Dibromo-3-Chloropropane	4.57E-12	1.10E-14	4.47E-12	1.07E-14	3.66E-11	8.78E-14	2.26E-11	5.42E-14	2.83E-12	7.02E-15	2.83E-12	7.02E-15
1,2-Dichloroethane	3.58E-12	0.00E+00	3.49E-12	0.00E+00	2.86E-11	0.00E+00	1.77E-11	0.00E+00	2.29E-12	0.00E+00	2.29E-12	0.00E+00
Indeno(1,2,3-cd)pyrene	7.61E-12	2.36E-12	7.43E-12	2.30E-12	6.08E-11	1.89E-11	3.76E-11	1.17E-11	4.87E-12	1.51E-12	4.87E-12	1.51E-12
alpha-BHC	7.45E-14	4.69E-13	7.28E-14	4.59E-13	5.96E-13	3.76E-12	3.69E-13	2.32E-12	4.77E-14	3.00E-13	4.77E-14	3.00E-13
Heptachlor	5.28E-14	2.37E-13	5.16E-14	2.32E-13	4.22E-13	1.90E-12	2.61E-13	1.17E-12	3.38E-14	1.52E-13	3.38E-14	1.52E-13
Methylene chloride	3.42E-12	5.64E-15	3.34E-12	5.51E-15	2.73E-11	4.51E-14	1.69E-11	2.79E-14	2.19E-12	3.81E-15	2.19E-12	3.81E-15
Trichloroethane	2.70E-12	1.62E-14	2.64E-12	1.58E-14	2.16E-11	1.29E-13	1.33E-11	8.00E-14	1.73E-12	1.04E-14	1.73E-12	1.04E-14
Total PCBs	8.28E-12	1.66E-11	8.09E-12	1.62E-11	6.62E-11	1.32E-10	4.09E-11	8.19E-11	5.30E-12	1.08E-11	5.30E-12	1.08E-11
Noncarcinogenic Risk												
COPC	On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker		Landscape Worker	Worker
	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ	ADD	HQ		
Arsenic	2.01E-10		1.96E-10		1.61E-09		9.93E-11		2.83E-08		2.83E-08	
Beryllium	1.05E-11	1.83E-08	1.02E-11	1.79E-08	8.37E-11	1.47E-05	5.18E-12	9.07E-07	1.53E-09	2.68E-04	1.53E-09	2.68E-04
Chromium	1.78E-09		1.72E-09		1.41E-08		8.71E-10		2.57E-07		2.57E-07	
Manganese	1.28E-08	8.96E-04	1.25E-08	8.76E-04	1.02E-07	7.17E-03	6.33E-09	4.43E-04	1.87E-08	1.31E-01	1.87E-08	1.31E-01
Chlorobenzene	4.81E-11	8.42E-09	4.70E-11	8.23E-09	3.85E-10	6.74E-08	2.38E-11	4.17E-09	7.02E-09	1.23E-06	7.02E-09	1.23E-06
1,1-Dichloroethane	9.47E-12	6.63E-11	9.26E-12	6.48E-11	7.58E-11	5.30E-10	4.69E-12	3.28E-11	1.38E-09	9.87E-09	1.38E-09	9.87E-09
Ethylbenzene	2.99E-11	1.05E-10	2.92E-11	1.02E-10	2.39E-10	8.37E-10	1.48E-11	5.17E-11	4.37E-09	1.53E-08	4.37E-09	1.53E-08
Heptachlor	1.48E-13		1.44E-13		1.18E-12		7.31E-14		2.16E-11		2.16E-11	
Methylene chloride	9.56E-12	1.12E-11	9.35E-12	1.09E-11	7.65E-11	8.93E-11	4.73E-12	5.52E-12	1.40E-09	1.63E-09	4.73E-12	5.52E-12
Toluene	6.21E-11	6.45E-10	6.07E-11	6.32E-10	4.97E-10	4.36E-09	3.07E-11	2.89E-10	9.06E-09	7.85E-08	3.07E-11	2.89E-10
Trichloroethane	7.55E-12	1.26E-09	7.38E-12	1.23E-09	6.04E-11	1.01E-08	3.73E-12	6.22E-10	1.10E-09	1.84E-07	3.73E-12	6.22E-10
1,1,1-Trichloroethane	6.06E-11	9.68E-11	5.95E-11	9.48E-11	4.87E-10	7.74E-10	3.01E-11	4.79E-11	8.89E-09	1.41E-08	3.01E-11	4.79E-11
Xylenes	1.08E-10		1.85E-10		1.35E-08		8.39E-11		2.48E-08		8.39E-11	
Summary												
On-site Worker		Construction Worker		Industrial / Commercial Worker		Mower		Landscape Worker				
ELCR for this pathway=		8.26E-11		6.76E-10		4.18E-10		5.41E-11				
HI for this pathway=		8.77E-04		7.18E-03		4.44E-04		1.31E-01				
Notes:												
ELCR: Excess lifetime cancer risks												
HI: Hazard Index												
COPC: Contaminants of potential concern												
LADD: Lifetime average daily dose												
ADD: Average daily dose												
HQ: Hazard quotient												

Table C-10.
GROUNDWATER VOLATILE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET
CLUSTER SITE: UNNAMED PARCEL

Carcinogenic Risk

$$LADD = (EPC_{air} \times IR \times EF \times ED) / (BW \times AT_c \times CF)$$

EPC = exposure point concentration in air (g/m³)

IR = inhalation rate (m³/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

AT_c = averaging time for carcinogens (day)

CF = Conversion Factor

$$ELCR = LADD \times SFI$$

SFI = Inhalation Slope Factor (kg-day/mg)

LADD = lifetime average daily dose (mg/kg-day)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF (days/year)	5	5	5		
AT _c (days)	25550	25550	25550		
IR (m ³ /day)	20	20	20	20	20
BW (kg)	70	70	70	70	70
CF (mg-g)	0.001	0.001	0.001	0.001	0.001

Noncarcinogenic Risk

$$ADD = EPC_{air} \times IR \times EF \times ED / (BW \times AT_n)$$

EPC = exposure point concentration in air (g/m³)

IR = inhalation rate (m³/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

AT_n = average time for noncarcinogens (years)

Conversion Factor = 1000

$$HQ = ADD / Rfd$$

ADD = average daily dose

Rfd = Volatile Inhalation Reference Dose (mg/kg-day)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF (days/year)	5	5	5		
AT _n (days)	9125	40	9125		
IR (m ³ /day)	20	20	20	20	20
BW (kg)	70	70	70	70	70
CF	0.001	0.001	0.001	0.001	0.001

Table C-11.
GROUNDWATER VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Carcinogenic Risk									
COPC	Henry's Law Constant	On-site Worker		Construction Worker		Industrial / Commercial Worker		LADD	ELCR
		LADD	ELCR	LADD	ELCR	LADD	ELCR		
Benzene	2.28E-01	1.19E-09	3.45E-11	4.76E-11	1.38E-12	1.19E-09	3.45E-11		
Noncarcinogenic Risk									
COPC	Henry's Law Constant	On-site Worker		Construction Worker		Industrial / Commercial Worker		ADD	HQ
		ADD	HQ	ADD	HQ	ADD	HQ		
Summary									
ELCR for this pathway=	HI for this pathway=	On-site Worker		Construction Worker		Industrial / Commercial Worker		LADD	ELCR
		LADD	ELCR	LADD	ELCR	LADD	ELCR		
		3.45E-11		1.38E-12		3.45E-11			
		0.00E+00		0.00E+00		0.00E+00			

Notes:
 ELCR: Excess lifetime cancer risks
 HI: Hazard index
 COPC: Contaminants of potential concern
 LADD: Lifetime average daily dose
 ADD: Average daily dose
 HQ: Hazard quotient

Table C-12.
SOIL VOLATILE INHALATION EXPOSURE FACTORS FOR LAKE CALUMET CLUSTER SITE: UNNAMED PARCEL

Carcinogenic Risk

$$LADD = (EPC \times ER \times IR \times EF \times ED) / (VF \times BW \times ATc)$$

EPC = Exposure Point Concentration (ug/kg)
ER = Exposure Rate (hours/day)
IR = Inhalation Rate (m³/hr)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
VF = Volatilization Factor (m³/kg)
BW = Body Weight (kg)
ATc = Averaging Time for Carcinogens (day)

$$VF = Q/C \times ((3.14 \times D \times T)^{1/2} / (2 \times R_o \times D)) \times CF$$

Q/C = Inverse of the mean concentration at the center of a square source = (g/m²-s)/(kg/m³)

D = Apparent Diffusivity (cm²/s)

T = Exposure Interval (s)

R_o = Dry Soil Bulk Density = g/cm³

CF = Conversion factor (10 E-4 m²/cm²)

$$D = (D_a^{1/2} \times D_i \times H') + (D_w^{1/2} \times D_w/n^2) \times (1/((\rho_w \times K_d) + D_w + (D_a \times H')))$$

D_a = Air-Filled Soil Porosity 0.13 For Subsurface Soil

D_i = Diffusivity in Air (cm²/s) Chemical Specific

H' = Henry's Law Constant Chemical Specific

D_w = Water-Filled Soil Porosity 0.3 For Subsurface Soil

D_w = Diffusivity in Water (cm²/s) Chemical Specific

n = Total Soil Porosity 0.43

ρ_w = Dry Soil Bulk Density (g/cm³) 1.5

K_d = Soil Water Partition Coeff = K_{oc} × f_{oc}
Chemical Specific
0.002

$$ELCR = LADD \times URF$$

URF = Inhalation Unit Risk (m³/ug)

LADD = lifetime average daily dose (ug/m³)

Exposure Factor	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
ED (years)	25	1	25	25	25
EF (days/year)	50	30	250	10	20
ATn (days)	9125	40	9125	9125	40
ATc (days)	25550	25550	25550	25550	25550
IR (m ³ /hr)	1.1	2.8	1.1	1.7	1.1
ER (hr/day)	1	5	8	8	4
BW (kg)	52	70	70	70	70

Noncarcinogenic Risk

$$ADD = EPC \times IR \times ER \times EF \times ED / (ATn \times VF \times BW)$$

EPC = exposure point concentration (ug/kg)

ER = exposure rate (hours/day)

IR = inhalation rate (m³/hr)

EF = exposure frequency (days/year)

ED = exposure duration (years)

ATn = average time for noncarcinogens (years)

VF = Volatilization Factor (m³/kg)

Conversion Factor = 1000

$$HQ = ADD / Rfc$$

ADD = average daily dose (m³/ug)

Rfc = Volatile Inhalation Reference Dose (ug/m³)

Table C-13.
SOIL VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

	Q/C	DI	H'	Dw	Koc	Kd	D	T	Ro	VF	T _{Construction}	VF _{Construction}
	g/sq.m/kg/cu.m)	(sq.cm/sec)		(sq.cm/sec)	cm ² /g	cu.cm/g	(sq.cm/sec)	Sec	g/cu.cm	cu.m/kg	Sec	cu.m/kg
COPC												
1,2-Dibromo-3-Chloropropane	85.81	2.12E-02	9.68E-04	7.02E-06	1.29E+02	2.58E-01	1.18E-06	7.90E+08	1.50E+00	1.31E+05	3.60E+06	8.84E+03
1,2-Dichloroethane	85.81	1.04E-01	4.01E-02	9.90E-06	1.74E+01	3.48E-02	7.34E-05	7.90E+08	1.50E+00	1.66E+04	3.60E+06	1.12E+03
Indeno(1,2,3-cd)pyrene	85.81	1.90E-02	6.56E-05	5.89E-06	3.47E+08	6.94E+03	5.41E-11	7.90E+08	1.50E+00	1.94E+07	3.60E+06	1.31E+08
alpha-BHC	85.81	1.42E-02	4.35E-04	7.34E-06	1.23E+03	2.48E+00	1.90E-07	7.90E+08	1.50E+00	3.27E+05	3.60E+06	2.21E+04
Heptachlor	85.81	1.10E-02	6.07E+01	5.89E-06	1.41E+06	2.82E+03	9.55E-07	7.90E+08	1.50E+00	1.48E+05	3.60E+06	9.84E+03
Methylene chloride	85.81	1.01E-01	8.98E-02	1.17E-05	1.17E+01	2.34E-02	1.62E-04	7.90E+08	1.50E+00	1.12E+04	3.60E+06	7.56E+02
Trichloroethene	85.81	7.90E-02	4.22E-01	9.10E-06	1.66E+02	3.32E-01	2.38E-04	7.90E+08	1.50E+00	9.24E+03	3.60E+06	6.23E+02
Chlorobenzene	85.81	7.30E-02	1.52E-01	8.70E-06	2.19E+02	4.38E-01	6.97E-05	7.90E+08	1.50E+00	1.71E+04	3.60E+06	1.15E+03
1,1-Dichloroethane	85.81	7.42E-02	2.30E-02	1.05E-05	3.16E+01	6.32E-02	2.86E-05	7.90E+08	1.50E+00	2.66E+04	3.60E+06	1.80E+03
Ethylbenzene	85.81	7.50E-02	3.23E-01	7.80E-06	3.63E+02	7.26E-01	1.03E-04	7.90E+08	1.50E+00	1.40E+04	3.60E+06	9.47E+02
Heptachlor	85.81	1.10E-02	6.07E+01	5.89E-06	1.41E+06	2.82E+03	9.55E-07	7.90E+08	1.50E+00	1.48E+05	3.60E+06	9.84E+03
Methylene chloride	85.81	1.01E-01	8.98E-02	1.17E-05	1.17E+01	2.34E-02	1.62E-04	7.90E+08	1.50E+00	1.12E+04	3.60E+06	7.56E+02
Toluene	85.81	8.70E-02	2.72E-01	8.60E-06	1.82E+02	3.64E-01	1.64E-04	7.90E+08	1.50E+00	1.11E+04	3.60E+06	7.52E+02
Trichloroethene	85.81	7.90E-02	4.22E-01	9.10E-06	1.66E+02	3.32E-01	2.38E-04	7.90E+08	1.50E+00	9.24E+03	3.60E+06	6.23E+02
1,1,1-Trichloroethane	85.81	7.80E-02	7.05E-01	8.80E-06	1.10E+02	2.20E-01	4.63E-04	7.90E+08	1.50E+00	6.82E+03	3.60E+06	4.47E+02
Xylenes	85.81	7.14E-02	2.15E-01	9.34E-06	3.74E+02	7.48E-01	6.48E-05	7.90E+08	1.50E+00	1.77E+04	3.60E+06	1.18E+03

Carcinogenic Risk														
	On-site Worker			Construction			Industrial /			Mower			Landscape Worker	
	LADD	ELCR		LADD	ELCR		LADD	ELCR		LADD	ELCR			
COPC														
1,2-Dibromo-3-Chloropropane	1.2E-05	8.1E-12		6.3E-05	4.3E-11		3.5E-04	2.4E-10		2.2E-05	1.5E-11		1.4E-05	9.6E-12
1,2-Dichloroethane	7.2E-05	0.0E+00		3.9E-04	0.0E+00		2.2E-03	0.0E+00		1.3E-04	0.0E+00		8.6E-05	0.0E+00
Indeno(1,2,3-cd)pyrene	1.3E-07	1.2E-11		7.1E-07	6.3E-11		3.9E-06	3.5E-10		2.4E-07	2.1E-11		1.9E-07	1.4E-11
alpha-BHC	7.7E-08	1.4E-10		4.1E-07	7.4E-10		2.3E-06	4.1E-09		1.4E-07	2.5E-10		9.1E-08	1.6E-10
Heptachlor	1.2E-07	1.6E-10		6.6E-07	8.4E-10		3.6E-06	4.7E-09		2.2E-07	2.9E-10		1.4E-07	1.9E-10
Methylene chloride	1.0E-04	4.8E-11		5.5E-04	2.6E-10		3.1E-03	1.4E-09		1.9E-04	8.9E-11		1.2E-04	5.8E-11
Trichloroethene	9.8E-06	1.7E-10		5.3E-04	9.1E-10		2.9E-03	5.0E-09		1.8E-04	3.1E-10		1.2E-04	2.0E-10

Noncarcinogenic Risk												
	On-site Worker			Construction			Industrial /			Mower		
	ADD	HQ		ADD	HQ		ADD	HQ		ADD	HQ	
COPC												
Chlorobenzene	9.5E-04	4.7E-05		1.2E+00	5.8E-02		2.8E-02	1.4E-03		1.7E-03	8.7E-05	
1,1-Dichloroethane	1.2E-04	2.4E-07		1.9E-01	2.9E-04		3.8E-03	7.1E-06		2.2E-04	4.4E-07	
Ethylbenzene	7.2E-04	7.2E-07		8.9E-01	8.8E-04		2.1E-02	2.1E-05		1.3E-03	1.3E-06	
Heptachlor	3.4E-07			4.2E-04			1.0E-05			6.3E-07		
Methylene chloride	2.9E-04	9.8E-08		3.9E-01	1.2E-04		8.5E-03	2.8E-06		5.3E-04	1.8E-07	
Toluene	1.8E-03	4.7E-06		2.3E+00	5.8E-03		5.6E-02	1.4E-04		3.4E-03	8.6E-06	
Trichloroethene	2.8E-04	1.3E-05		3.4E-01	1.6E-02		8.2E-03	3.9E-04		5.1E-04	2.4E-05	
1,1,1-Trichloroethane	3.1E-03	1.4E-06		3.8E+00	1.7E-03		9.2E-02	4.2E-05		5.7E-03	2.6E-06	
Xylenes	3.2E-03			3.9E+00			8.9E-02			5.8E-03		
											8.7E-01	

Table C-13.
SOIL VOLATILE INHALATION EXPOSURE EVALUATION FOR LAKE CALUMET CLUSTER SITE:
UNNAMED PARCEL

Summary					
	On-site Worker	Construction	Industrial /	Mower	Landscape Worker
ELCR for this pathway=	5.31E-10	2.86E-09	1.58E-08	9.76E-10	6.31E-10
HI for this pathway=	5.31E-05	6.52E-02	1.58E-03	9.76E-05	1.44E-02

Notes:
 ELCR: Excess lifetime cancer risks
 HI: Hazard Index
 COPC: Contaminants of potential concern
 LADD: Lifetime average daily dose
 ADD: Average daily dose
 HQ: Hazard quotient

Table C-14.
**SUMMARY OF HUMAN HEALTH RISK ASSESSMENT FOR LAKE CALUMET CLUSTER SITE:
 UNNAMED PARCEL**

Summary of Human Risk Assessment for Soil, Sediment, Surface water and Groundwater

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	3.E-06	1.E-06	2.E-05	1.E-05	1.E-06
Total HI	1.E-02	6.E-01	5.E-02	2.E-02	1.E-01

Summary of Human Risk Assessment for Soil, Sediment and Surface water

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	3.E-06	1.E-06	2.E-05	1.E-05	1.E-06
Total HI	1.E-02	6.E-01	5.E-02	2.E-02	1.E-01

Summary of Human Risk Assessment for Soil

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	3.E-06	1.E-06	2.E-05	1.E-05	1.E-06
Total HI	1.E-02	6.E-01	5.E-02	2.E-02	1.E-01

Summary of Human Risk Assessment for Groundwater

	On-site Worker	Construction Worker	Industrial / Commercial Worker	Mower	Landscape Worker
Total ELCR	2.E-07	9.E-09	2.E-07		
Total HI	4.E-04	4.E-03	4.E-04		

Table C-14.
**SUMMARY OF HUMAN HEALTH RISK ASSESSMENT FOR LAKE CALUMET CLUSTER SITE:
 UNNAMED PARCEL**

Notes:
 ELCR: Excess lifetime cancer risks
 HI: Hazard index
 Bold shaded area indicated ELCR or HI exceedances for the receptor

Table C-15.
EXCEEDANCES SUMMARY OF CHEMICAL OF POTENTIAL CONCERN
FOR LAKE CALUMET CLUSTER SITE: UNNAMED PARCEL

COPCs of Carcinogenic Risk in Soil

COPC	Receptors
Arsenic	Industrial/Commercial Worker, Mower
Benzo(a)pyrene	Industrial/Commercial Worker, Mower

Notes:

ELCR: Excess lifetime cancer risks

HI: Hazard Index

Carcinogenic exceedances: ELCR is greater than 1.00E-06

Noncarcinogenic exceedances: HI is greater than 1.00E+00

—

B

B

Baseline Ecological Risk Assessment (BERA), 2001

**FINAL REPORT
ECOLOGICAL RISK ASSESSMENT
LAKE CALUMET CLUSTER SITES
CHICAGO, ILLINOIS**

NOVEMBER 2001



PREPARED BY:

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Attached please find the following document prepared under this work assignment:

FINAL REPORT
ECOLOGICAL RISK ASSESSMENT
LAKE CALUMET CLUSTER SITES
CHICAGO, ILLINOIS

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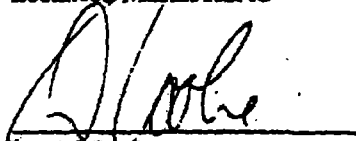
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FINAL REPORT
ECOLOGICAL RISK ASSESSMENT
LAKE CALUMET CLUSTER SITES
CHICAGO, ILLINOIS
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ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
Ag	silver
Alburn	Alburn Incinerator
As	arsenic
ASTM	American Society for Testing and Materials
Be	beryllium
BNA	base, neutral, and acid extractable compounds
BTAG	Biological Technical Advisory Group
Cd	cadmium
Co	cobalt
COPC	contaminant of potential concern
Cr	chromium
Cu	copper
DDD	dichloro diphenyl dichloroethane
DDE	dichloro diphenyl ethane
DO	dissolved oxygen
E&E	Ecology and Environment
ERA	ecological risk assessment
ERTC	Environmental Response Team Center
FBI	Family Biotic Index
Fe	iron
GPS	global positioning system
Hg	mercury
HMWPAH	high molecular weight polycyclic aromatic hydrocarbons
HQ	hazard quotient
IL	Illinois
LCC	Lake Calumet Cluster
LCC-1	Pond LHL1, north side.
LCC-2	Pond LHL1, south side.
LCC-3	Pond LHL2, north side
LCC-4	Pond LHL2, south side.
LCC-5	Southeast Pond, north side
LCC-6	Southeast Pond, south side
LCC-7	Alburn Depositional Area.
LL3	Land and Lakes #3
LMWPAH	low molecular weight polycyclic aromatic hydrocarbons
LOAEL	lowest observable adverse effect level
MDL	method detection limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
Ni	nickel
NOAEL	no observable adverse effect level
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCB	polychlorinated biphenyl

ACRONYMS AND ABBREVIATIONS (cont.)

RCRA	Resource Conservation and Recovery Act
REAC	Response Engineering and Analytical Contract
Sb	antimony
Se	selenium
SL	screening level
SLERA	screening level ecological risk assessment
SOIL-1	Paxton I, E&E soil sampling site ID #S14
SOIL-2	Alburn, E&E soil sampling site ID #S26
SOIL-3	Alburn, E&E soil sampling site ID #2S16
SOIL-4	U.S. Drum, E&E soil sampling site ID #S50
SOIL-5	U.S. Drum, E&E soil sampling site ID #61
SOIL-6	Unnamed Parcel, E&E soil sampling site ID #S66
SOP	standard operating procedure
SVOC	semi-volatile organic compound
TAL	target analyte list
Tl	thallium
TV	tolerance value
U.S. EPA	United States Environmental Protection Agency
USD	U.S. Drum II
V	vanadium
VOC	volatile organic compound
WA	work assignment
Zn	zinc

1.0 INTRODUCTION

1.1 Purpose

The objective of this project is to evaluate the ecological risks associated with the Lake Calumet Cluster Sites (LCC), located in Chicago, Illinois (IL). Encompassed in the project are steps 3 through 7 of the 8 step Ecological Risk Assessment (ERA) Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (U.S. EPA 1997).

1.2 Background

The LCC site is located near the southeast corner of Lake Calumet, in Chicago, Cook County, IL (Figure 1). The site is approximately 200 acres, and is composed of seven individual properties: Paxton I, Paxton II, Paxton Lagoons, Alburn Incinerator (Alburn), U.S. Drum II (USD), Land and Lakes #3 (LL3), and an unnamed parcel. The site is bordered on the north by Interlake/Big Marsh, on the west by Stony Island Avenue, on the east by the Norfolk and Western Railroad right-of-way, and on the south by 122nd Street (Ecology and Environment 1999).

The Paxton properties, now inactive, were general use landfills in the early 1970s, accepting household and industrial wastes and sludge (Ecology and Environment 1999). Paxton II also accepted some hazardous and non-hazardous "special wastes" (Weston 1998).

The Alburn property was used as a trench landfill for ten years, until 1977, when its primary use was expanded to include hazardous waste storage, transfer, and incineration. Alburn handled a wide variety of organic chemicals and wastes. The facility had its waste permit revoked in 1982 for Resource Conservation and Recovery Act (RCRA) violations. Alburn continued to accept bulk waste until January, 1983. On July 5, 1985, two on-site drums exploded from heat expansion and a subsequent chemical reaction. The United States Environmental Protection Agency (U.S. EPA) ordered an immediate removal action of all visible sources of hazardous materials from the site. In addition, the top 6 inches of soil, assumed to be the most contaminated, were excavated (Ecology and Environment 1999).

The USD property was used for 30 years as a municipal and industrial dump site, until the mid-1970s. In 1979, the facility became a waste drum storage and transfer facility which was shut down later that same year. Over 34,000 gallons of liquid and semisolid wastes were removed after facility closure. In 1984 and 1985, a U.S. EPA removal action cleaned up 1,500 buried drums, which had been punctured to allow their contents to leak out. In addition, 435 cubic yards of soil and 62,000 gallons of contaminated water were removed (Ecology and Environment 1999).

The LL3 property is a permitted, active landfill. The unnamed parcel has been shown to be filled with household waste and industrial or construction debris (Ecology and Environment 1999).

1.3 Scope

The scope of this project included the collection of soil, sediment, and surface water for chemical and toxicological analysis; and tissue (fish, crayfish, and earthworm) for chemical analysis. The field investigations were conducted by U.S. EPA Environmental Response Team Center (ERTC) and personnel from the Response, Engineering, and Analytical Contract (REAC). Activities were

directed at both the aquatic and terrestrial aspects of the site. Water, sediment, and soil were collected the week of January 29, 2001; toxicity tests were conducted in February 2001; and fish and crayfish were collected the week of April 9, 2001.

2.0 TECHNICAL APPROACH

2.1 Screening Level Ecological Risk Assessment and Preliminary Problem Formulation

A screening level ecological risk assessment (SLERA) was conducted to determine if there was sufficient ecological risk associated with the exposure of biota to site-related contaminants to warrant a more intensive, site-specific ERA (Lockheed Martin 2000); Appendix A. The following steps were completed for this screening level risk assessment:

- A literature search was conducted to identify life history information for selected risk model indicator species, and to evaluate the potential for ecotoxicological effects from the site contaminants.
- A preliminary problem formulation was prepared to evaluate the risk to ecological receptors. This assessment consisted of the following steps:
 - Exposure scenarios were determined based on site contaminant levels, the extent and magnitude of contamination, and the toxicological mechanisms of the contaminants.
 - Model receptor species were selected based on species present, or potentially present on site, the availability of literature-based toxicity information, and the potential for exposure to contaminants based on habitat use or behavior.
 - Exposure pathways were determined for each model indicator species.
- 10 benchmarks were identified.
- The benchmarks were compared with levels of contaminants on site.
- 10 contaminants of potential concern (COPCs) were identified for this study.

The results of the SLERA were used to identify the COPCs for this ERA. Any contaminant that exceeded its benchmark value for soil, sediment, or water, or that was detected in a matrix for which a benchmark did not exist, was identified as a COPC. The SLERA assumed that receptors were exposed to the highest concentration detected in the considered media, and that the contaminant was biologically available and completely assimilated. On the basis of concentration and toxicity, the SLERA identified a total of 112 COPCs. Of these, 6 were low molecular weight polycyclic aromatic hydrocarbons (LMWPAHs), 11 were high molecular weight PAHs (HMWPAHs), 35 were semi-volatile organic compounds (SVOCs), 15 were volatile organic compounds (VOCs), 15 were pesticides, 7 were polychlorinated biphenyls (PCBs), and 23 were metals. A complete list of the COPCs can be found in Table 1. It should be noted that inclusion of a COPC on this list is simply an indication that the compound was present, but that based upon the available information, it could not be concluded that the chemical posed no ecological risk.

2.2 Refined Problem Formulation

A refined problem formulation was prepared using the parameters outlined in the preliminary problem formulation, and enhanced by gathering the following information:

- Exposure and effect profiles for each model receptor species, and each site COPC.
- A risk characterization was conducted which involved the calculation of hazard

quotients (HQ) for each model species for a range of exposure scenarios, as appropriate to refine the COPCs to specific assessment endpoints.

This completed the baseline ERA. Subsequent sections describe each assessment endpoint and the data requirements necessary to complete the assessment.

The problem formulation phase encompasses the development of assessment endpoints, risk questions directly related to the assessment endpoints, and the development of measures of effects (measurement endpoints). The latter are the means of answering risk questions, followed by the development of a sampling design for data acquisition. Based on these assessment endpoints, specific risk questions (testable hypotheses) were developed, and measures of effects were selected for the evaluation of the risks posed. The study design incorporated knowledge of existing literature on environmental investigations performed in and around the LCC Site, the relationship between a test response and the mechanism of environmental toxicity of site COPCs, and the generation of information which would facilitate the interpretation of testing results regarding the influence of toxicity versus non-contaminant related stress.

2.3 Selection of Assessment Endpoints

Refined assessment endpoints were developed for this site, based on habitat types present at or near the site, the type of contaminants, and the potentially present species. Following each assessment endpoint are the testable hypotheses and proposed measurement endpoints. For those assessment endpoints having multiple measurement endpoints, a weight-of-evidence approach was used in the ERA which allowed integration of all measurement endpoints into a single conclusion. A weight-of-evidence evaluation implies that there are multiple lines of evidence, but not all lines of evidence have equal strength. When multiple lines of evidence for a particular assessment endpoint lead to the same conclusion, the level of confidence in the risk estimate is increased. If multiple lines of evidence generated apparent conflicts, the evidence relative to the mechanisms of toxicity was used in evaluating the level of confidence in the risk estimate. Similarly, some measurement endpoints were used for multiple assessment endpoints (e.g., concentration of COPCs in soil, sediment, and surface water).

Assessment endpoints are explicit expressions of the actual ecological resources that are to be protected. Valuable ecological resources include those without which ecosystem function would be significantly impaired, or those providing critical components (e.g., habitat). Appropriate selection and definition of assessment endpoints are critical to the utility of a risk assessment, as they focus assessment design and analysis. It is not practical, or possible, to directly evaluate potential risks to all of the individual components of an ecosystem, so assessment endpoints are used to focus on particular components of the ecosystem that could be adversely affected by site specific contaminants. By evaluating and protecting these assessment endpoints, the ecosystem as a whole should also be protected. A review of the habitat of the LCC sites and its associated wetlands provided information for the selection of assessment endpoints. A variety of invertebrates, vertebrates, and plants inhabit the area. In addition, birds and mammals inhabiting this and adjacent areas could prey on the flora and fauna inhabiting the study area. Therefore, the assessment endpoints focused on these biological groups. In general, endpoints are aimed at the viability of terrestrial and aquatic populations.

2.4 Measurement Endpoints

Each of the testable hypotheses was evaluated using one or more measurement endpoints. The number of measurement endpoints chosen for each assessment endpoint was determined by the type of habitat, the mechanism(s) of toxicity, and the feasibility of collecting the supporting data. When more than one measurement endpoint was used to evaluate a single assessment endpoint, a weight-of-evidence approach was employed, whereby the measurement endpoints were treated as lines of evidence. The overall risk to each assessment endpoint was then determined based on the results of the evaluation of each line of evidence, having taken into consideration the degree of importance of each line of evidence.

The measurement endpoints were selected to represent the mechanisms of toxicity and exposure pathways for the assessment endpoints and to answer questions posed by the testable hypotheses for each assessment endpoint. Where adverse effects were observed, the measurement endpoints were also used in developing preliminary ecotoxicologically-based remedial goals. For this study, the following measurement endpoints, or lines of evidence, were identified for each of the assessment endpoints evaluated in this risk assessment.

2.5 Conceptual Model

The conceptual model is based on contaminant and habitat characteristics to identify critical exposure pathways to the selected assessment endpoints. At the LCC Site, contaminants in the water, sediment, and soil may come in contact with the aquatic, benthic, and terrestrial receptors inhabiting or using the area. Benthic invertebrates in LCC Site ponds may be exposed to site contaminants through direct contact with and/or ingestion of the sediment and overlying water. Aquatic vertebrates may be exposed to site contaminants via direct contact with water and sediment, ingestion of water, incidental ingestion of sediment adhered to food items, and ingestion of contaminated food. Mammals and birds may be exposed to site contaminants via ingestion of contaminated food, incidental ingestion of sediment or soil, and ingestion of surface water.

Based on this conceptual model, and dependent upon the availability of information, the following pathways will be considered in this risk assessment:

- I. Fish
 - Direct contact with water
 - Direct contact with sediment
- II. Benthic Invertebrates
 - Direct contact with water
 - Direct contact with sediment
- III. Amphibians
 - Direct contact with water
 - Direct contact with sediment
- IV. Insectivorous Bird
 - Ingestion of invertebrates
- V. Omnivorous Waterfowl
 - Ingestion of invertebrates
 - Ingestion of fish
- VI. Piscivorous Bird

- Ingestion of fish
- VII. Omnivorous Mammal
 - Ingestion of invertebrates
 - Ingestion of fish
- VIII. Carnivorous Mammal
 - Ingestion of invertebrates
- IX. Soil Macroinvertebrate
 - Direct contact with soil
 - Ingestion of soil
- X. Plant Community
 - Direct contact with soil

2.6 Assessment Endpoint #1: Viability of Wetland Structure and Functioning

The health of the wetlands/ponds has a direct impact on the health of the entire ecosystem. The maintenance of the structure and function of the wetlands is important to the ecosystem since it provides critical habitat for many species of plants and animals. Wetlands also process energy, organic matter, and nutrients. Biota utilizing the wetland area often rely extensively on the resources (e.g., forage) provided by the ponds to support survival, growth, and reproduction. In addition to providing a stopover and/or breeding ground for migratory species, wetlands usually provide high quality edge habitat for a variety of relatively sedentary birds, reptiles, amphibians, and mammals, which in turn rely on the ponds to forage. The sedentary species that generally congregate near ponds due to habitat and food availability are in turn preyed upon by more far-ranging species that utilize the wetland. In this assessment, the term wetlands refers to both the open water habitat (ponds) and to traditional wetlands. In most instances, sampling was conducted in the ponds, and the results applied to both ponds and wetlands.

2.6.1 Testable Hypotheses for Assessment Endpoint #1:

Are levels of site contaminants in sediment, soil, and surface water sufficient to cause adverse alterations to the structure and viability of wetland communities?

2.6.2 Measurement Endpoint for Assessment Endpoint #1:

The overall functioning of the wetland communities on the site was inferred through the evaluation of measurement endpoints for assessment endpoints 2, 3, 4, 5, 6, 7, 8, 9, and 10. These components provide information regarding the trophic levels and habitats within the site and subsequently offer insights into the overall functioning of the habitat.

2.7 Assessment Endpoint #2: Fish Recruitment and Nursery Functioning

Fish function in the transfer of nutrients and energy within a pond, and as forage items for organisms that inhabit the pond and its feeder streams. Several predators rely solely or primarily on fish as forage. Fish typically provide a large proportion of the biomass utilizing a pond and are in a wide range of trophic positions (e.g., predators, bottom feeders, etc.) in pond communities. Due to these factors, impairment to fish communities would have strong impacts on nutrient and energy cycling in the pond and overall ecosystem health.

2.7.1 Testable Hypotheses for Assessment Endpoint #2:

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment in fish that inhabit the wetlands?

2.7.2 Measurement Endpoint for Assessment Endpoint #2:

Two lines of evidence were used to assess the effects of contamination within the site ponds on the fish communities that inhabit them.

Samples of surface water from the site were tested for aquatic toxicity using larval fathead minnows (*Pimephales promelas*). The results of the toxicity test were statistically analyzed to determine if survival or growth of fish were adversely affected, as compared with the laboratory control. The results were also correlated to the measured concentrations of the COPCs in the water to determine if a dose-response relationship exists between observed toxicity and the detected COPCs.

Fish were collected from site ponds and subjected to whole body tissue analysis for COPCs.

2.8 Assessment Endpoint #3: Viable and Functioning Benthic Invertebrate Communities

Benthic invertebrate communities constitute a significant portion of the base of the food chain for aquatic ecosystems. Impacts to benthic invertebrate communities may have significant direct and indirect effects (e.g., loss or reduction of forage) on higher trophic organisms (e.g., fish, birds, herpetiforms). Invertebrates process organic material, and play an important role in nutrient and energy transfer in pond and marsh ecosystems.

2.8.1 Testable Hypotheses for Assessment Endpoint #3:

Are levels of site contaminants in surface water and sediment sufficient to cause adverse alterations to the structure and function of aquatic invertebrate communities?

Are levels of site contaminants in sediment and/or water sufficient to cause toxic effects or reproductive impairment in aquatic invertebrates that inhabit the ponds and marshes on and adjacent to the site?

2.8.2 Measurement Endpoint for Assessment Endpoint #3:

Three lines of evidence were used to assess the effects of contamination within the site ponds on the benthic invertebrate communities that inhabit them.

A bioassessment survey of the benthic invertebrate community conducted August–September 1998 was used to determine the overall health of the benthic community in this ERA.

Sediment samples from ponds LHL 1, LHL 2, and Southeast Pond were collected for use in sediment toxicity tests using the freshwater amphipod, *Hyalella azteca*. The results of the toxicity tests were statistically analyzed to determine if survival or growth of the

amphipod was adversely affected as compared with a reference area or the laboratory control. The results were then correlated to the measured concentrations of the COPCs in the sediment to determine if a dose-response relationship existed between the observed toxicity and any of the COPCs.

Sediment samples were collected and analyzed for PAHs, VOCs, SVOCs, PCBs, pesticides, and metals. Sediment contaminant levels were compared with literature-based benchmarks to determine whether the contamination was sufficient to cause adverse effects to benthic invertebrates.

2.9 Assessment Endpoint #4: Viable and Functioning Amphibian Populations

Embryo and larval stages are critical periods for amphibians and other species that share similar life histories. Examination of the effect of contaminants on amphibians during these stages provides a direct measure of reproductive success and a measure of recruitment success into the adult population. Amphibians represent a significant source of forage to higher trophic level organisms (e.g., birds, fish, and mammals). Amphibians are also considered to be sensitive to a wide range of contaminants and are considered to be a sensitive indicator species for adverse effects to the ecosystem.

2.9.1 Testable Hypotheses for Assessment Endpoint #4:

Are levels of site contaminants sufficient to cause adverse alterations to the development, growth or reproductive capacity of the amphibian community?

2.9.2 Measurement Endpoint for Assessment Endpoint #4:

Results of benthic invertebrate toxicity tests were used to evaluate the effects of contamination in the site ponds on amphibian populations. Since the developmental stages of some amphibians' life cycles are spent in close proximity to the sediment, the results of the *H. azteca* toxicity test were used to estimate whether amphibians are potentially at risk.

2.10 Assessment Endpoint #5: Viability and Recruitment of Insectivorous Birds

Insectivorous birds are important in the population regulation of insects, such as mosquitoes. Impacts to insectivorous birds would allow species of insects to obtain higher population levels than would typically occur in a system that was not impacted. In addition, insectivorous birds are important in nutrient processing and energy transfer between the aquatic and terrestrial environment.

2.10.1 Testable Hypotheses for Assessment Endpoint #5:

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to insectivorous birds that utilize the site and adjacent areas?

2.10.2 Measurement Endpoint for Assessment Endpoint #5:

A food chain accumulation model based on the life history of the yellow headed blackbird (*Xanthocephalus xanthocephalus*) was employed using site specific data (invertebrate

contaminant concentrations) to estimate the dose of COPCs to which insectivorous birds are exposed. Estimated dosages were compared with literature values to determine if a risk to the survival and reproduction of insectivorous birds exists as a result of site contamination. The earthworm, *Eisenia foetida*, was used as a surrogate invertebrate to represent both soil invertebrates and emergent aquatic insects. Laboratory toxicity and bioaccumulation studies of site soil were performed, and the subsequent tissue analyses were used as site specific invertebrate contamination concentrations.

2.11 Assessment Endpoint #6: Viability and Recruitment of Omnivorous Waterfowl

Omnivorous waterfowl were selected for evaluation because of their diverse methods of foraging. Of the bird species utilizing the system, omnivorous waterfowl have been reported to have the greatest soil/sediment ingestion rates. Soil/sediment ingestion can account for substantial dietary exposure in accumulation models. Omnivorous waterfowl help regulate the growth of aquatic vegetation, algae, and benthic invertebrates. Omnivorous waterfowl are an important pathway by which nutrients and energy may be transferred between the aquatic and terrestrial environment.

2.11.1 Testable Hypotheses for Assessment Endpoint #6:

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment in omnivorous waterfowl that utilize the site and adjacent areas?

2.11.2 Measurement Endpoint for Assessment Endpoint #6:

A food chain accumulation model based on the life history of the mallard duck (*Anas platyrhynchos*) was employed using site specific data (invertebrate and fish contaminant concentrations) to estimate the dose of COPCs to which omnivorous waterfowl are exposed. Data from whole body tissue analysis of fish collected from the site ponds, and data from laboratory bioaccumulation testing with earthworms were used. The earthworm, *Eisenia foetida*, was used as a surrogate invertebrate to represent emergent aquatic insects. Estimated dosages were compared to literature values to determine if a risk to the survival and reproduction of omnivorous waterfowl exists as a result of exposure to site contaminants.

2.12 Assessment Endpoint #7: Viability and Recruitment of Herbivorous Birds

Herbivorous birds were selected for evaluation because of their method of foraging. Herbivorous birds have been reported to have high incidental soil ingestion rates, which can account for substantial dietary exposure in accumulation models. Herbivorous birds help regulate the growth and diversity of vegetation surrounding water bodies. Herbivorous birds are an important pathway by which nutrients and energy may be transferred between primary producers and consumers.

2.12.1 Testable Hypotheses for Assessment Endpoint #7:

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment in herbivorous birds that utilize the site and adjacent areas?

2.12.2 Measurement Endpoint for Assessment Endpoint #7:

A food chain accumulation model based on the life history of the American wigeon (*Anas americana*) was employed using site-specific data to estimate the dosages of COPCs to which herbivorous birds are exposed. Since suitable vegetation was not available on the site, data from laboratory bioaccumulation testing with plants was used in concert with field collected water and soil COPC concentrations. The ryegrass *Lolium perenne* was used to represent native vegetation. Estimated doses were compared to literature values to determine if a risk to the survival and reproduction of herbivorous birds exists as a result of exposure to site contaminants.

2.13 Assessment Endpoint #8: Viability of Piscivorous Birds

Piscivorous birds are an upper trophic-level organism that rely primarily on fish as forage. Foraging behavior of piscivorous birds represents a pathway by which nutrients and energy are transferred between aquatic and terrestrial ecosystems. Predators are often required to keep prey species in check, and impacts to predators could cause detrimental population increases in prey species.

2.13.1 Testable Hypotheses for Assessment Endpoint #8:

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment in piscivorous birds that utilize the site and adjacent areas?

2.13.2 Measurement Endpoint for Assessment Endpoint #8:

A food chain accumulation model based on the life history of the black-crowned night heron (*Nycticorax nycticorax*) was employed using site-specific data (invertebrate and fish tissue contaminant concentrations) to estimate dosages of COPCs to which piscivorous birds are exposed. Data from whole body tissue analysis of fish collected from the site ponds, and data from laboratory bioaccumulation testing with earthworms were used. Estimated doses were compared to literature values to determine if a risk to the survival and reproduction of piscivorous birds exists as a result of exposure to site contaminants.

2.14 Assessment Endpoint #9: Viability of Omnivorous Mammals

Omnivorous mammals help to regulate benthic invertebrate and fish populations. Omnivorous mammals are an important pathway by which nutrients and energy are transferred between the terrestrial and aquatic environment. In many urban and/or suburban ecosystems, these species typically represent the highest trophic levels and therefore, for contaminants that biomagnify, would be receiving the highest doses of contaminants from their forage.

2.14.1 Testable Hypotheses for Assessment Endpoint #9:

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to omnivorous mammals that utilize the site and adjacent areas?

2.14.2 Measurement Endpoint for Assessment Endpoint #9:

A food chain accumulation model based on the life history of the raccoon (*Procyon lotor*) was developed using site-specific data (fish and invertebrate contaminant concentrations), to estimate the dosages of COPCs to which omnivorous mammals are exposed. Estimated doses were compared with literature values to determine if a potential risk to the survival and reproduction of omnivorous mammals exists as a result of exposure to site contaminants.

2.15 Assessment Endpoint #10: Viability of Carnivorous Mammals

Carnivorous mammals are upper trophic-level organisms that selectively forage on lower trophic level organisms such as small mammals. Foraging behavior of carnivorous mammals represents a pathway by which nutrients and energy are transferred to higher trophic levels within the terrestrial ecosystem. Predators also are often required to keep prey in check, and impacts to predators could cause detrimental population increases in prey species.

2.15.1 Testable Hypotheses for Assessment Endpoint #10:

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment in carnivorous mammals that utilize the site and adjacent areas?

2.15.2 Measurement Endpoint for Assessment Endpoint #10:

A food chain accumulation model based on the life history of the shrew (*Blarina brevicauda*) was employed using site-specific data (invertebrates) to estimate the dose of COPCs to which carnivorous mammals are exposed. Estimated doses were compared with literature values to determine if a potential risk to the survival and reproduction of carnivorous mammals exists as a result of exposure to site contamination.

2.16 Assessment Endpoint #11: Functioning of the Soil Macroinvertebrate Community

The soil macroinvertebrate community is typically diverse taxonomically, morphologically, and physiologically, and is often numerically abundant. Additionally, the soil macroinvertebrate community of a terrestrial ecosystem plays a key role in ecosystem functions such as nutrient cycling, organic matter processing, and is an important food resource for the terrestrial community including insectivorous mammals and birds. Moreover, there is a direct linkage between the macroinvertebrate community and other ecological communities, as well as between ecosystem functions.

This assessment endpoint focuses on the terrestrial portion of the study area, and is aimed at an ecologically fit and viable soil macroinvertebrate community. The habitat within the study area has been modified substantially as a result of the direct deposition of waste materials containing contaminants and the indirect translocation of contaminants via erosion and deposition.

2.16.1 Testable Hypotheses for Assessment Endpoint #11:

Are the levels of contaminants sufficient to cause adverse effects in soil macroinvertebrates?

2.16.2 Measurement Endpoints for Assessment Endpoint #11:

The toxicity and bioaccumulation potential of COPCs in soil was evaluated through solid-phase toxicity tests using earthworms (*Eisenia foetida*).

The soil function was evaluated through nutrient and COPC analyses. The level of nutrients in the soil was evaluated as one measure of the ability of the soil to support an ecologically healthy community consisting of plants and animals.

2.17 Assessment Endpoint #12: Viability of the Plant Community

Terrestrial plants provide nesting and cover habitat for wildlife. Trees, shrubs, and tall grasses provide materials and habitat for most species of birds, as well as many mammalian species such as squirrels, rabbits, and mice. These plants also provide the basis for the food production for the ecosystem generating fruit, seeds, and leaves.

2.17.1 Testable Hypotheses for Assessment Endpoint #12:

Are the levels of site contaminants sufficient to cause adverse effects to vegetation?

2.17.2 Measurement Endpoints for Assessment Endpoint #12:

The toxicity and bioaccumulation potential of COPCs in soil through solid-phase toxicity testing using ryegrass (*Lolium perenne*) was evaluated.

The soil function was evaluated through nutrient and COPC analyses. The level of nutrients in the soil was evaluated as one measure of the ability of the soil to support an ecologically healthy community consisting of plants and animals.

3.0 METHODS

A field investigation was necessary to collect the information described above for use in a baseline ERA. This investigation involved the collection of soil, surface water, sediment, and fish. In addition to physical and chemical analyses, samples were analyzed using toxicity testing. These tasks are described.

Field sampling was performed in January 2001 for soil, surface water, sediment, and fish tissue. No fish were caught during the January sampling trip, likely because of the temperature (the ponds were covered with approximately 8 inches of ice). Fish were successfully obtained during a follow-up sampling trip in April 2001.

3.1 Aquatic Sampling

3.1.1 Sampling Locations

The study area included three ponds, and a depositional area on the Alburn property that may have previously been used as a holding pond (Figure 1). For the three ponds, sampling locations were situated in areas exhibiting similar habitat characteristics including substrate composition, vegetation, topographic relief, and land use. In an effort to increase the

interpretive powers of the data collected, samples were collocated. A total of seven locations were chosen and established by the field investigators.

LCC-1	Pond LHL1, north side
LCC-2	Pond LHL1, south side
LCC-3	Pond LHL2, north side
LCC-4	Pond LHL2, south side.
LCC-5	Southeast Pond, east side
LCC-6	Southeast Pond, west side
LCC-7	Alburn Depositional Area

With the exception of location LCC-7, all aquatic sampling sites were sampled for surface water, sediment, and fish. LCC-7 was only sampled for sediment.

3.1.2 Surface Water Sampling

Two surface water samples were collected from each sampling location and composited into a single sample for analysis. Due to accumulation of ice on the ponds, holes were made in the ice using a pick axe. Surface water samples were collected from these holes directly into the appropriate containers by hand, per ERT/REAC standard operating procedure (SOP) #2013, *Surface Water Sampling*. To avoid the incidental incorporation of suspended sediment into the sample, water was collected prior to other sampling activities that may have disturbed the sediment. Water samples were collected at approximately half the water depth from each sampling location.

3.1.3 Surface Water Quality Measurements

Water quality parameters were measured *in-situ* at each sampling location using a Hydrolab 4a multi-parameter water quality meter. Temperature, pH, dissolved oxygen (DO), conductivity, and turbidity were measured. Hydrolab calibration was checked prior to data collection, and again after data collection was completed. The Hydrolab was used in accordance with the manufacturer's operating manual.

3.1.4 Sediment Sampling

Sediment was collected from each sampling location except LCC-4, using a decontaminated ponar dredge or shovel per ERT/REAC SOP #2016, *Sediment Sampling*. A volume of sediment sufficient to fulfill the analytical requirements was collected from several collocated grabs, placed into a 2-gallon plastic bucket, and homogenized with a stainless steel trowel. Aliquots for laboratory analyses were dispensed into appropriate sample containers.

3.1.5 Fish and Crayfish Collection

Forage fish (for this assessment, any fish less than approximately four inches were considered forage) were sampled for the evaluation of tissue residues of COPCs. Fish were captured using small fish traps baited with partially opened cans of cat food and bread. Three fish traps were placed at each location totaling six traps per pond. The fish from each

location were composited into one sample. Because of the need for tissue analysis to evaluate the potential transfer of COPCs to piscivorous birds (e.g., black-crowned night heron), whole fish were weighed, wrapped in aluminum foil, placed in a plastic bag, and placed on dry ice as per ERT/REAC SOP# 2039 *Fish Handling and Processing*. No fish were captured from pond LHL2, or from the Southeast Pond. Crayfish were collected only from ponds LHL1 and LHL2. Fish and crayfish were shipped via overnight delivery to the appropriate laboratory.

3.1.6 Toxicity Evaluations

3.1.6.1 Amphipod Sediment Toxicity Test

Solid-phase sediment toxicity evaluations using *Hyalella azteca* were performed in accordance with the U.S. EPA document: *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates* (Ingersoll *et al.* 1994), and American Society for Testing and Materials method E1706-95 "Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh Water Invertebrates" (ASTM 1995). Testing was designed to provide data concerning the availability and toxicity of contaminants present in the sediment (Nebeker *et al.* 1984, Nebeker *et al.* 1986). Sediment for the solid-phase toxicity evaluation was collected from all sampling locations except LCC-4.

3.1.6.2 Larval Fish Toxicity Test

Surface water was evaluated using *Pimephales promelas*, according to U.S. EPA methods (Lewis *et al.* 1994) and ERT/REAC SOP# 2026, *7-Day Static Toxicity Test using Larval Pimephales promelas*, to provide data concerning the availability and toxicity of contaminants present in the water. The toxicity test used 100% site water (no dilution), along with a laboratory control. Standard reference toxicant testing was performed concurrently.

3.1.7 Benthic Macroinvertebrate Sampling

No benthic macroinvertebrate sampling was conducted during this field effort. Ecology and Environment personnel collected benthic samples from August 24, 1998 through September 3, 1998 (Ecology and Environment 1999) and the methods and results of their study are reiterated here. E&E collected macroinvertebrate samples either from submerged objects or sieved from sediments collected with a ponar dredge. Macroinvertebrates were classified from Indian Ridge Marsh and the on-site ponds. Each location was evaluated for the total number of taxa found at that location, the total number of organisms, the lowest tolerance value (TV) assigned to organisms at that location, and the Family Biotic Index (FBI). Tolerance values ranged from 0 to 10, with 0 being the least pollution tolerant organism, and 10 being the most pollution tolerant organism. The FBI was calculated by multiplying the number of organisms in each taxon by the TV for that taxon, summing the products, and dividing by the total number of organisms in the sample. For taxa with ranges of TVs, the average was used, and taxa with no known TV (e.g., *Hemiptera*) were not included in the equation.

3.2 Terrestrial Sampling

3.2.1 Terrestrial Sampling Locations

A total of six soil sampling locations were sampled. Sample locations were specified, and marked by global positioning system (GPS) by the field investigators. They are as follows:

- SOIL 1 Paxton I, Ecology and Environment (E&E) soil sampling site ID #S14.
- SOIL 2 Alburn, E&E soil sampling site ID #S26.
- SOIL 3 Alburn, E&E soil sampling site ID #S16.
- SOIL 4 U.S. Drum, E&E soil sampling site ID #S50.
- SOIL 5 U.S. Drum, E&E soil sampling site ID #61.
- SOIL 6 Unnamed Parcel, E&E soil sampling site ID #S66.

Ecology and Environment location numbers refer to a previous risk assessment performed at the site (Ecology and Environment 1999). These sampling locations were judged to be "hot spots" for COPCs.

3.2.2 Soil Sampling

Surficial soil (0 to 3 inches below ground surface) was collected from all locations using a decontaminated pick and shovel as per ERT/REAC SOP #2012, *Soil Sampling*. Individual grabs were placed into one 5-gallon plastic bucket and two 2-gallon plastic buckets and homogenized. Aliquots for laboratory analyses were dispensed into appropriate sample containers.

3.2.3 Terrestrial Plant Sampling

Because sampling was performed in the winter, none of the site vegetation was deemed appropriate for tissue analysis. Therefore, no vegetation samples were collected, as originally planned.

3.2.4 Toxicity Evaluations

3.2.4.1 Earthworm Soil Toxicity/Accumulation

Acute soil toxicity bioassays using the earthworm *Eisenia foetida* were performed according to American Society for Testing and Materials (ASTM) guide E1676-97, "Standard Guide for Conducting Laboratory Soil Toxicity or Bioaccumulation Tests with the Lumbricid Earthworm *Eisenia foetida*" (ASTM 1997). Testing provided data concerning the availability and toxicity of contaminants present in the soil (USEPA 1989). *E. foetida* is widely distributed in soil, is an important component of the terrestrial invertebrate community, and often comprises a significant proportion of the soil biomass. In addition to being in intimate physical contact with the substrate, *E. foetida* feeds on detrital matter and vegetative debris incorporated into the soil.

3.2.4.2 Ryegrass Soil Toxicity/Accumulation

Soil toxicity evaluations using the perennial ryegrass *Lolium perenne* were performed in accordance with ASTM guide E1963-98 "Standard Guide for Conducting Terrestrial Plant Toxicity Tests" (ASTM 1998), and ASTM guide E1598-94 "Standard Practice for Conducting Early Seedling Growth Tests" (ASTM 1994). Testing provided data concerning the availability and toxicity of contaminants present in the soil (USEPA 1989). Soil samples that were found to be acutely toxic were not included in the tissue accumulation endpoint. *L. perenne* is a widely distributed monocot grass, that is commonly used as a surrogate laboratory test species.

3.3 Sampling Equipment Decontamination

The following sampling equipment decontamination procedure was employed prior and subsequent to sampling at each location per ERT/REAC SOP #2006, *Sampling Equipment Decontamination*:

- 1 physical removal
- 2 nonphosphate detergent wash (e.g., Liquinox)
- 3 potable water rinse
- 4 distilled/deionized water rinse
- 5 10 percent nitric acid rinse
- 6 distilled/deionized water rinse
- 7 acetone rinse
- 8 distilled/deionized water rinse
- 9 air dry

3.4 Standard Operating Procedures

Sample Documentation was completed per the following REAC SOPs:

- REAC SOP #2002, *Sample Documentation*
- REAC SOP #4005, *Chain of Custody Procedures*

Sample Packaging and Shipment was completed per the following REAC SOP:

- REAC SOP #2004, *Sample Packaging and Shipment*

Sampling Techniques and field activities were conducted per the following ERT/REAC SOPs:

- ERT/REAC SOP #2012, *Soil Sampling*
- ERT/REAC SOP #2013, *Surface Water Sampling*
- ERT/REAC SOP #2016, *Sediment Sampling*

3.5 Waste Disposal

Investigation derived waste (e.g., personal protective equipment) was disposed of in accordance with all state and federal regulations. All samples were maintained per the work plan.

4.0 RESULTS

Most sample matrices collected were analyzed for target analyte list (TAL) metals, Pesticides/PCBs, VOCs, and base, neutral, and acid extractables (BNAs). Some of the components of the BNA analysis include HMWPAHs and LMWPAHs and SVOCs, which were identified in the SLERA as COPCs. In addition, certain groups of compounds (e.g., chlordanes, aroclors, HMWPAHs, etc.) are discussed as the sum of the concentration detected. In instances where an estimated value of an analyte is included in the total sum of a particular group of compounds, that group was considered estimated (an analyte which was detected, but was below the MDL was considered to be estimated).

Worm tissue from bioaccumulation testing was analyzed for PCBs and TAL metals. Worm tissue data must also be viewed with caution, because the tissue samples which had been frozen immediately after toxicity testing were inadvertently allowed to thaw, and were held at room temperature for several days prior to analysis. The samples were submitted for analysis after REAC data validators and the U.S. EPA ERT WAM agreed that PCBs and metals would not be significantly impacted (i.e., they would not have degraded) by the tissues not being frozen.

4.1 Results of the Chemical Analysis of Surface Water

Surface water samples collected from site ponds were analyzed for TAL metals, Pesticides/PCBs, VOCs, and BNAs. In addition, water quality parameters (temperature, DO, pH, conductivity, and turbidity) were measured at each location. The final validated analytical results can be found in Appendix B.

4.1.1 Target Analyte List Metals

Surface water collected from site ponds was analyzed for TAL metals (Table 2). Location LCC-5 & LCC-6 had the highest concentrations of metals.

4.1.2 Pesticides/Polychlorinated Biphenyls

Surface water collected from site ponds was analyzed for Pesticides/PCBs (Table 3). Aroclors 1242 and 1260 were detected at Location LCC-5 & LCC-6, but no other Pesticides/PCBs were measured above the MDL.

4.1.3 Volatile Organic Compounds

Surface water collected from site ponds was analyzed for VOCs (Table 4). Location LCC-5 & LCC-6 had the most VOCs detected (10 total). Concentrations were relatively low throughout the study area.

4.1.4 Base, Neutral, and Acid Extractables

Surface water collected from site ponds was analyzed for BNAs (Table 5). Location LCC-5 & LCC-6 had the most BNA compounds detected (4 total). Concentrations were relatively low throughout the study area.

4.1.5 *In Situ* Water Quality

Water quality parameters were measured at each sampling location (Table 6). Dissolved oxygen was low (< 3 milligrams per liter [mg/L]) at LCC-1, LCC-5, and LCC-6 and was not greater than 7 mg/L at any sampling location. There was a thick cover of ice (= 8 inches) on each of the ponds, and water temperatures were low (0–1 °C). There was a strong sulfur odor associated with the water from the Southeast Pond (Locations LCC-5 and LCC-6).

4.2 Results of the Chemical Analysis of Sediment

Sediment collected from site ponds was analyzed for TAL metals, Pesticides/PCBs, VOCs, and BNAs (which included HMWPAHs and LMWPAHs). The final validated analytical results can be found in Appendix B.

4.2.1 Target Analyte List Metals

Sediment collected from site ponds was analyzed for TAL metals (Table 7). Location LCC-7 had the highest concentrations of metals detected.

4.2.2 Pesticides/Polychlorinated Biphenyls

Sediment collected from site ponds was analyzed for Pesticides/PCBs (Table 8). Location LCC-7 had the most pesticides detected (10 total). Location LCC-5 had the highest total concentrations of PCBs detected. In general, Pesticides/PCBs were either below the MDL or were at relatively low concentrations.

4.2.3 Volatile Organic Compounds

Sediment collected from site ponds was analyzed for VOCs (Table 9). Location LCC-7 had the most VOCs detected (23 total) at typically the greatest concentrations. In general, the concentrations of VOCs detected throughout the study area were relatively low.

4.2.4 Base, Neutral, and Acid Extractables

Sediment collected from site ponds was analyzed for BNAs (Table 10). Location LCC-7 had the most BNAs detected (13 total).

4.3 Results of the Chemical Analysis of Soil

Soil collected from site was analyzed for TAL metals, Pesticides/PCBs, VOCs, and BNAs (which included HMWPAHs and LMWPAHs). The final validated analytical results can be found in Appendix B.

4.3.1 Target Analyte List Metals

Soil collected from the site was analyzed for TAL Metals (Table 11). Location SOIL-6 had the highest concentrations of As (14 mg/kg), Pb (2900 mg/kg), and Hg (3.0 mg/kg).

4.3.2 Pesticides/Polychlorinated Biphenyls

Soil collected from the site was analyzed for pesticides/PCBs (Table 12). Location SOIL-1 had the most pesticides/PCBs detected (9 total). Concentrations of pesticides/PCBs detected throughout the study area were relatively low, with the exception of 13,000 µg/kg aroclor 1242 at Location SOIL-6.

4.3.3 Volatile Organic Compounds

Soil collected from the site was analyzed for VOCs (Table 13). For those VOCs detected, concentrations throughout the study area were relatively low.

4.3.4 Base, Neutral, and Acid Extractables

Soil collected from the site was analyzed for BNAs (Table 14). Concentrations of BNAs detected throughout the study area were relatively low.

4.4 Results of the Chemical Analysis of Fish, Crayfish, and Earthworm Tissue

Fish and crayfish were collected from site ponds for TAL metals, Pesticides/PCBs, and BNAs (which included HMWPAHs and LMWPAHs). As stated above, earthworms from bioaccumulation tests were only analyzed for TAL metals and PCBs because the tissue samples were inadvertently thawed and maintained at room temperature for several days prior to analysis. Though PCB and metals analyses were thought to be largely unaffected, the analyzed concentrations are considered to be estimates. The final analytical results are in Appendix B. Because of the observed toxic effects of soils from all locations on *L. perenne*, contaminants were not measured in ryegrass tissue.

4.4.1 Target Analyte List Metals

4.4.1.1 Fish Tissue

Fish collected from site ponds were analyzed for TAL Metals (Table 15). Metals concentrations appeared to be consistent between samples.

4.4.1.2 Crayfish Tissue

Crayfish collected from site ponds were analyzed for TAL Metals (Table 15). Concentrations of most metals in crayfish tissue were typically greater than those measured in fish tissue. Tissue metals concentrations appeared to be consistent between crayfish samples.

4.4.1.3 Earthworm Tissue

Earthworms used in the bioaccumulation tests were analyzed for TAL Metals (Table 16). In general, concentrations of metals detected were consistent between samples.

4.4.2 Pesticides/Polychlorinated Biphenyls

4.4.2.1 Fish Tissue

Fish collected from site ponds were analyzed for Pesticides/PCBs (Table 17). Fish from both locations had measurable concentrations of DDT breakdown products, and Aroclor 1254 and 1260. Concentrations were similar between locations.

4.4.2.2 Crayfish Tissue

Crayfish collected from site ponds were analyzed for pesticides/PCBs (Table 17). No pesticides were measured above the MDL. Aroclor 1254 and 1260 were detected in crayfish from LHL1 Crayfish.

4.4.2.3 Earthworm Tissue

Tissue from earthworms used in bioaccumulation tests was analyzed for PCBs (Table 18). Earthworms exposed to soil from Location SOIL-6 had the greatest concentrations of PCBs.

4.4.3 Base, Neutral, and Acid Extractables

4.4.3.1 Fish Tissue

Fish collected from site ponds were analyzed for BNAs (Table 19). The only BNAs measured above the MDL in fish tissue were phthalates, which are typically associated with laboratory contamination (plasticizers) and were also detected in the laboratory blanks.

4.4.3.2 Crayfish Tissue

Crayfish collected from site ponds were analyzed for BNAs (Table 19). The only BNAs measured above the MDL in crayfish tissue were phthalates, which are typically associated with laboratory contamination (plasticizers) and were also detected in the laboratory blanks.

4.5 Results of the Toxicity Evaluations

4.5.1 Amphipod (*Hyaletta azteca*)

The results of the amphipod toxicity test are summarized in Table 20, and the complete report may be found in Appendix C. Survival of *H. azteca* exposed to sediments from Locations LCC-2, LCC-5, and LCC-6 was significantly reduced compared with those exposed to laboratory control sediment. For Locations LCC-1, LCC-3, and LCC-7 survival was not affected, and the mean final weight of the test organisms was greater than that of the laboratory control.

4.5.2 Fathead Minnow (*Pimephales promelas*)

The results for the fathead minnow toxicity test are summarized in Table 21, and the complete report may be found in Appendix D. Survival of *P. promelas* exposed to site waters from locations LCC-5 & LCC-6 and LCC-3 & LCC-4 was significantly lower than those exposed to the laboratory control water. For Location LCC1 & LCC2, where survival was not affected, the mean final weight of the exposed minnows was not significantly different from that of the laboratory control.

4.5.3 Earthworm (*Eisenia foetida*)

The results for the earthworm bioaccumulation and toxicity test using *E. foetida* are summarized in Table 22. The complete report may be found in Appendix E. The initial 28 day bioaccumulation test was considered to be invalid due to poor survival in the laboratory control. The testing laboratory felt this was due to poor organism health. Therefore, a 14 day toxicity test was run, using *E. foetida* from a different supplier. The results of the 14 day test showed a significant difference in survival between the laboratory control (98%) and Soil-3 (78%). There were no significant differences between the control and the other locations. Correlation analysis was conducted on *E. foetida* toxicity parameters (survival and weight loss), and soil COPCs for locations SOIL-1, SOIL-2, SOIL-3, SOIL-4, SOIL-5, and SOIL-6. COPCs included in the analysis were TAL metals, pesticides, PCBs, VOCs, and BNAs. Methylene chloride was positively correlated with *E. foetida* weight loss ($r=0.89$).

4.5.4 Ryegrass (*Lolium perenne*)

The results of *L. perenne* testing are summarized in Table 23. The complete report may be found in Appendix F. Ryegrass survival was negatively affected in Soil-3. One or more sublethal parameters (e.g., shoot length, shoot weight, root weight) were negatively affected in all soil samples. Due to the observed toxicity associated with all soil samples, COPCs were not measured in ryegrass tissue. Correlation analysis was conducted on ryegrass toxicity parameters (survival, average shoot length, average shoot weight, average root weight) and soil COPCs for Locations SOIL-1, SOIL-2, SOIL-3, SOIL-4, SOIL-5, and SOIL-6. Significant positive correlations with shoot weight, shoot length, and root weight were found for Sb, Pb, and Zn. Correlation coefficients (r) ranged from 0.89 to 0.96. Magnesium resulted in statistically significant correlations with all three toxicity parameters as well, however, the data were negatively correlated with r ranging from -0.84 to -0.95. Barium was negatively correlated with ryegrass survival with $r=-0.86$. Calcium, Mn, and V were negatively correlated with ryegrass shoot weight and shoot length, with r ranging from -0.91 to -0.95. Of the VOCs, only 1,1-dichloroethane was negatively correlated with ryegrass survival ($r=-0.83$), and positively correlated with rye grass average root weight, ($r=0.89$). Of the BNAs, only naphthalene was negatively correlated with ryegrass survival ($r=-0.84$).

4.6 Benthic Macroinvertebrate Community

The following discussion is a brief summation of the benthic macroinvertebrate survey performed by Ecology and Environment during an earlier assessment of the LCC site (Ecology and

Environment 1999), consult the report for more details. Based on the tolerance values (TVs) and BFI, pond LHL1 and the two most southern samples from Indian Ridge Marsh had the lowest number of organisms, and the lowest benthic species diversity. Only four organisms were found in samples collected from pond LHL1. Although pond LHL2 contained a higher number of organisms per sampling effort than pond LHL1, only two taxa were found in Pond LHL2. The southeast pond contained species diversity comparable to the Indian Ridge Marsh, with two samples having TV values of 6. The E&E report concluded that the macroinvertebrates with TVs lower than 5 may not have been able to survive in the sediment and water conditions existing in the ponds at that time. The authors also suggested that the fact that only more tolerant species existed on the LCC site confirmed the ecological impact that was suggested by the screening level exceedances.

5.0 BENCHMARK COMPARISONS OF SURFACE WATER, SOIL, AND SEDIMENT COPCs

Concentrations of COPCs detected in LCC site surface water, soil, and sediment were compared to screening level toxicity benchmarks published by U.S. EPA Region III Biological Technical Assistance Group (BTAG) (Davis 1995). Surface water analytical results were also compared to U.S. EPA Water Quality Criteria (WQC) (U.S. EPA 1999).

5.1 Surface Water

Location LCC-5 & LCC-6 had the highest concentrations of metals of all of the samples collected. Concentrations of Cr, Cu, Fe, Pb, V, and Zn in water from Location LCC-5 & LCC-6 and Pb at LCC-1 & LCC-2 exceeded U.S. EPA Region III BTAG Screening Levels (SL) for freshwater fauna (Davis 1995) (Table 2). Concentrations of Al and Pb exceeded U.S. EPA WQC at all locations. Concentrations of Cr and Zn were greater than WQC at Location LCC-5 & LCC-6. The MDLs for Cd, Hg, and arsenic (As) were greater than the BTAG SL values. The MDLs for Cd and Cu were greater than the WQC values.

Aroclors 1242 and 1260 exceeded the BTAG SL at Location LCC-5 & LCC-6 (Table 3).

Concentrations of BNAs in surface water did not exceed BTAG SLs (for those compounds for which SLs were available) (Table 5).

5.2 Sediment

Location LCC-7 had the highest concentrations of metals detected, except for Al (Table 7). BTAG SLs were exceeded most frequently at Location LCC-7 (As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn) although all sampling locations exceeded the SLs for at least two metals.

Location LCC-5 had the highest concentrations of PCBs detected (Table 8). BTAG SLs were exceeded for dichloro diphenyl dichloroethane (DDD; 3 locations), DDE (dichloro diphenyl ethane; all locations), and PCBs (all locations). However, the exceedances at LCC-1, LCC-2, and LCC-3 for PCBs should be viewed with caution, as the MDL was greater than the SL value.

Concentrations of BNAs in site sediments were often greater than the BTAG SLs, however, the MDLs were generally greater than the SL value (Table 10).

5.3 Soil

Concentrations of Al and Cr exceeded BTAG SL values for flora at all locations (Table 11). Lead and Ag also exceeded BTAG SL values for flora at Location SOIL-6. Concentrations of Cr, Fe, and Pb exceeded the BTAG SL values for fauna at all locations.

Concentrations of aldrin, DDD, DDE, g-chlordane, and PCBs exceeded BTAG SL values for flora (and fauna when available) at SOIL-6 (Table 12). Locations SOIL-1, SOIL-2, SOIL-3, and SOIL-5 each had SL exceedences for flora.

Although concentrations of BNAs in site soils frequently exceeded BTAG SL values, the MDLs were almost always greater than the SL value (Table 14).

6.0 FOOD CHAIN MODELS

6.1 Methods

The hazard quotient (HQ) method (Barnthouse *et al.* 1986; USEPA 1997) was employed in this assessment. The HQ method compares exposure concentrations to toxicity reference values (TRVs) based on ecological endpoints such as mortality, reproductive failure, or reduced growth. These sublethal toxicity values are derived from the literature, and are intended to represent a lower dose over a longer duration of exposure. Such exposure would result in subtle effects, manifested at the population level over the long term. Both no observable adverse effect level (NOAEL) and lowest observable adverse effect level (LOAEL) values were used to determine HQs.

The comparison is expressed as a ratio of potential intake values to population effect levels:

$$\text{Hazard Quotient} = \frac{\text{Exposure Concentration (Maximum)}}{\text{Chronic Effect Level (e.g., NOAEL or LOAEL)}}$$

In this assessment, food chain models were used to determine whether a potential exists for exposure at a level that presents a risk to organisms inhabiting the site. Additionally, the results of the models and the bioaccumulation data were used to determine whether there is a plausible transport mechanism to off-site areas that could pose a risk.

The effect level values (NOAEL and LOAEL) for each COPC were based on studies published in the literature. Exposure concentrations were estimated by employing a food chain model for each receptor species (e.g., the black crowned night heron) associated with an assessment endpoint (e.g., viability of aquatic feeding birds). In these food chain models, ingestion rates of each COPC for each receptor species were determined based on measured concentrations of each contaminant in food items collected at the site. Concentrations of COPCs in soil, sediment, and water were not included in the food chain model calculations. The exposure concentrations and toxicity values were entered into the HQ equation, and a HQ was calculated. If the HQ was greater than 1.0, based on a chronic NOAEL, it was concluded that there was a chronic risk from that contaminant to the ecological receptor in question. If the hazard quotient was greater than 1.0, based on a chronic LOAEL for a particular contaminant, it was concluded that there was the potential to produce an actual adverse effect on survival, reproduction, or growth of the ecological receptor in question.

Receptor species from different trophic levels were used for food chain accumulation modeling. Organisms which are likely to be exposed to contaminants because of specific behaviors, patterns of habitat use, or feeding habits were selected for evaluation in this assessment. The availability of appropriate toxicity information on which risk calculations were based was also an important consideration. The surrogate receptor species selected for this assessment included the yellow-headed black bird, mallard, black crowned night heron, raccoon, and shrew.

One exposure scenario was evaluated for each receptor species. In general, the model used conservative life history parameters, and maximum concentrations of contaminants in one food item. In some instances, additional models were run using maximum COPC concentrations in multiple food items. Life history parameters from published literature were used in the food chain models. Conservative life history parameters included the lowest published adult body weight and the highest published ingestion rates for food. The following were calculated:

- I. HQ for an insectivorous bird (yellow headed blackbird) using conservative life history parameters, conservative contaminant concentrations, and one food item (earthworms).
- II. HQ for an omnivorous waterfowl (mallard duck) using conservative life history parameters, conservative contaminant concentrations, and two food items (fish and earthworms).
- III. HQ for a piscivorous bird (black-crowned night heron) using conservative life history parameters, conservative contaminant concentrations, and one food item (fish).
- IV. HQ for a piscivorous bird (black-crowned night heron) using conservative life history parameters, conservative contaminant concentrations, and one food item (earthworms).
- V. HQ for a piscivorous bird (black-crowned night heron) using conservative life history parameters, conservative contaminant concentrations, and two food items (fish and earthworms).
- VI. HQ for an omnivorous mammal (raccoon) using conservative life history parameters, conservative contaminant concentrations, and three food items (fish, crayfish, and earthworms).
- VII. HQ for a carnivorous mammal (short-tailed shrew) using conservative life history parameters, conservative contaminant concentrations, and one food item (earthworms).

Model results may be biased. Samples were not collected from a reference area, and although the sampling design did not attempt to establish a contamination gradient, food items (fish and crayfish) were collected only from the "cleaner" part of the contaminated areas. Attempts were made to collect food items from the more contaminated areas of the site, but the efforts were not successful (no fish or crayfish were present in the more heavily contaminated ponds). Acute toxicity to earthworms occurred in soils from the more contaminated areas of the site, surviving organisms that had been exposed to toxic soils were not considered appropriate for tissue analyses. Therefore, no tissue data was available for the most contaminated areas of the site.

This assessment utilized simplifying assumptions in the food chain models, since it is difficult to mimic a complete diet. According to food chain dynamics, maximum stability results when a large

number of species eat a restricted diet, or when a smaller number of species eats a widely varied diet. The seasonal availability of prey also results in a prey specialization by the consumer. Given these factors and the conservative approach used in the food chain models, piscivorous and insectivorous receptor species were assumed to only consume a single food item at the LCC site.

The following sections summarize the model calculated risk for each receptor, documenting the environmental contamination levels that exceed the threshold for adverse effects to the assessment endpoints (U.S. EPA 1997). The boundary for the adverse effects threshold was the NOAEL-based HQ value.

6.2 Results of Risk Calculations

The results of the food chain exposure models are summarized in Table 24. Input parameters and calculations for the models may be found in Appendix H.

Total PCBs: The primary model calculated risk from the LCC site was from PCBs. There was model calculated risk to all receptor communities. NOAEL-based HQs ranged from 1.01 (black crowned night heron eating fish) to 148.76 (yellow-headed blackbird eating earthworms). Both the NOAEL and LOAEL-based HQs were greater than 1.0 for the yellow headed blackbird, the black-crowned night heron (eating earthworms), the raccoon, and the short-tailed shrew.

Total BNAs: There was model calculated risk to the omnivorous mammal community from total BNAs, as the NOAEL-based HQ was greater than 1.0.

Aluminum: There was model calculated risk to the insectivorous bird community from Al, as both the NOAEL and LOAEL-based HQs were greater than 1.0. There was also model calculated risk to the carnivorous mammal community from Al, as the NOAEL-based HQ was greater than 1.0.

Arsenic: There was model calculated risk to the carnivorous mammal community from As, as the NOAEL-based HQ was greater than 1.0.

Antimony: TRVs for Sb were not available for birds, therefore, no HQs were calculated. There was model calculated risk to the both the carnivorous and omnivorous mammal communities. Both the NOAEL and LOAEL-based HQs were greater than 1.0 for the carnivorous mammal community, while only the NOAEL-based HQ was greater than 1.0 for the omnivorous mammal community.

Barium: There was model calculated risk to the both the carnivorous and omnivorous mammal communities from Ba. Both the NOAEL and LOAEL-based HQs were greater than 1.0 for the carnivorous mammal community, while only the NOAEL-based HQ was greater than 1.0 for the omnivorous mammal community.

Cadmium: There was model calculated risk to the insectivorous bird and carnivorous mammal communities from Cd. The NOAEL-based HQ was greater than 1.0 for both groups.

Chromium: There was model calculated risk to insectivorous birds from Cr, where both the NOAEL and LOAEL-based HQs were greater than 1.0. There was model calculated risk to the black-crowned night heron (eating earthworms), as the NOAEL-based HQ was greater than 1.0.

Copper: There was model calculated risk to the insectivorous bird community from Cu, as the NOAEL-based HQ was greater than 1.0.

Iron: There was model calculated risk to the carnivorous mammal community from Fe, as the NOAEL-based HQ was greater than 1.0.

Lead: There was model calculated risk to the insectivorous bird community from Pb, as both the NOAEL and LOAEL-based HQs were greater than 1.0. There was model calculated risk to the black-crowned night heron eating a diet of 100% earthworms, and eating a diet of 50% fish and 50% earthworms. The NOAEL-based HQ was greater than 1.0. There was model calculated risk to the carnivorous mammal community, as the NOAEL-based HQ was greater than 1.0.

Mercury: There was model calculated risk to both the insectivorous bird and mammal communities from Hg. Both the NOAEL and LOAEL-based HQs were greater than 1.0 for both receptor species.

Selenium: After PCBs, Se posed the highest model calculated risk to communities inhabiting the LCC Site. There was model calculated risk to all receptors except the omnivorous mammal community from Se. The insectivorous bird and carnivorous mammal communities had both NOAEL and LOAEL-based HQs greater than 1.0, while the remaining receptors had only NOAEL-based HQs greater than 1.0.

Sodium: There was model calculated risk to the insectivorous bird community from Na, where both the NOAEL and LOAEL-based HQs were greater than 1.0. There was also risk to the carnivorous mammal community, as the NOAEL-based HQ was greater than 1.0.

Vanadium: There was model calculated risk to the carnivorous mammal community from V, as the NOAEL-based HQ was greater than 1.0.

Zinc: There was model calculated risk to the insectivorous bird community from Zn, where both the NOAEL and LOAEL-based HQs were greater than 1.0. There was also risk to the carnivorous mammal community, as the NOAEL-based HQ was greater than 1.0.

7.0 EVALUATION OF ASSESSMENT ENDPOINTS

Twelve assessment endpoints and their associated testable hypotheses and measurement endpoints were identified in the work plan for the LCC Site. Each of the assessment endpoints is described above, in Section 2, and are evaluated below.

7.1 Assessment Endpoint #1: Viability of Wetland Structure and Functioning

Based on the results of analyses supporting assessment endpoints 2, 3, 4, 5, 6, 7, 8, 9, and 10, the viability of LCC Site wetlands is at risk (see subsequent discussions for details).

7.2 Assessment Endpoint #2: Fish Recruitment and Nursery Functioning

There was risk to fish populations from site pond water. In laboratory toxicity tests, surface water from Location LCC-3 & LCC-4, and Location LCC-5 & LCC-6 significantly reduced the survival of larval fathead minnows (*P. promelas*).

Concentrations of six metals and PCBs in water from Location LCC-5 & LCC-6 exceeded U.S. EPA Region III BTAG SL values for freshwater fauna.

7.3 Assessment Endpoint #3: Viable and Functioning Benthic Macroinvertebrate Community

The benthic macroinvertebrate community was impacted at the LCC Site. Macroinvertebrate samples from 20 wetland locations were sorted, identified, and enumerated by E&E in 1998 (Ecology and Environment 1999). Their results revealed assemblages typically associated with poor water quality conditions. There was low species diversity and richness, the benthic communities were dominated by species with high TVs, and the communities had high FBIs.

In laboratory toxicity tests, sediment from Locations LCC-2, LCC-5, and LCC-6 significantly reduced the survival of freshwater amphipods (*H. azteca*).

Region III BTAG SL values for fauna were often exceeded for metals (up to 8 analytes at Location LCC-7), DDT breakdown products, and PCBs.

7.4 Assessment Endpoint #4: Viable and Functioning Amphibian Populations

Survival of the surrogate species, *H. azteca*, exposed to sediment from Locations LCC-2, LCC-5, and LCC-6 was significantly reduced, as compared with the lab control. Therefore, certain life stages of the amphibian community which spend time in or near the sediment, may also be at risk.

7.5 Assessment Endpoint #5: Viability and Recruitment of Insectivorous Birds

Based on the results of a food chain accumulation model for the yellow headed blackbird (*Xanthocephalus xanthocephalus*), insectivorous birds are at risk from PCBs, Al, Cd, Cr, Cu, Pb, Hg, Se, Na, and Zn.

7.6 Assessment Endpoint #6: Viability and Recruitment of Omnivorous Waterfowl

Based on the results of a food chain accumulation model for the mallard duck (*Anas platyrhynchos*), omnivorous waterfowl are at risk from PCBs and Se.

7.7 Assessment Endpoint #7: Viability and Recruitment of Herbivorous Birds

Because of the acute and chronic toxic effects observed in the ryegrass (*L. perenne*) toxicity test, and because toxic effects were associated with all soil samples collected at the LCC site, investigators believed that tissue analysis for COPC concentrations was not appropriate. Furthermore, due to the winter sampling event, plant tissues could not be collected *in situ*. Therefore, there was insufficient data available to generate food chain exposure models for herbivorous birds.

7.8 Assessment Endpoint #8: Viability of Piscivorous Birds

Based on the results of a food chain accumulation model for the black-crowned night heron (*Nycticorax nycticorax*), the piscivorous avian community is at risk from PCBs and Se, regardless of the dietary input parameters. The piscivorous avian community is also at risk from Cr and Pb when eating earthworms, and from Pb when eating earthworms and fish.

7.9 Assessment Endpoint #9: Viability of Omnivorous Mammals

Based on the results of a food chain accumulation model for the raccoon (*Procyon lotor*), the omnivorous mammal community is at risk from PCBs, BNAs, Sb, and Ba.

7.10 Assessment Endpoint #10: Viability of Carnivorous Mammals

Based on the results of a food chain accumulation model for the shrew (*Blarina brevicauda*), the carnivorous mammal community is at risk from PCBs, Al, As, Sb, Ba, Cd, Fe, Pb, Hg, Se, Na, V, and Zn.

7.11 Assessment Endpoint #11: Functioning of the Soil Macroinvertebrate Community

The soil macroinvertebrate community at the LCC site is at risk. In laboratory toxicity tests, *E. foetida* survival was significantly lower at SOIL-3 than at other site locations or in the laboratory control. Concentrations of Cr, Fe, and Pb exceeded the Region III BTAG SL values for fauna at all locations. BNAs often exceeded the SL values, especially at Location SOIL-6.

7.12 Assessment Endpoint #12: Viability of the Plant Community

The plant community at the LCC Site is at risk. In laboratory toxicity tests, survival of the ryegrass, *L. perenne*, was significantly reduced in plants exposed to soil from Location Soil-3. One or more sublethal parameters negatively affected plant viability in all site soil samples. Concentrations of Al and Cr exceeded Region III SL values for flora at all locations. Lead and Ag also exceeded SL values for flora at Location SOIL-6. Concentrations of aldrin, DDD, DDE, g-chlordane, and PCBs exceeded Region III SL values for flora at SOIL-6. Locations SOIL-1, SOIL-2, SOIL-3, and SOIL-5 also exceeded the Region III BTAG SL for one or more analytes.

8.0 ASSUMPTIONS AND SOURCES OF UNCERTAINTY

8.1 Assumptions

A contaminant concentration was considered to exceed the threshold, and demonstrate model calculated risk to the given receptor if the NOAEL-based HQ was greater than 1.0.

If neither the NOAEL- nor the LOAEL-based HQs was greater than 1.0, it was concluded that there is no model calculated risk to the given receptor.

No adjustments were made to the receptor life history parameters to account for regional factors. Only information for adult organisms was used, with no gender differentiation. In instances where more than one data set was combined to derive a mean, each data set was assumed to be equally weighted. Where a data set was broken into males and females, those numbers were equally weighted and averaged before the data set was combined with another data set.

An area use factor (AUF) of 1 was assumed for all species using the site for feeding. Therefore, it was assumed that the receptors obtain 100% of their food from each location evaluated using the food chain model.

Contaminants in food items were assumed to exhibit 100% absorption efficiency and were assumed not to be metabolized and/or excreted during the life of the receptor.

COPC concentrations accumulated by earthworm and fish tissues were assumed to be at steady state.

Dietary ingestion information was obtained from the literature for the receptor species. However, simplifications of complex diets were performed for the receptors to utilize site specific tissue, sediment, and water data. In some cases, ingestion rates were based on information for a similar species or calculated from an allometric equation. It was assumed that these estimated ingestion rates were representative of the true ingestion rates for the receptor species in question.

A literature search was conducted to determine the chronic toxicity of the contaminants of concern when ingested by the indicator species. If no toxicity values could be located for the receptor species, values reported for a closely related species were used. All studies were critically reviewed to determine whether study design and methods were appropriate. When values for chronic toxicity were not available, LD₅₀ (median lethal dose) values were used. For purposes of this risk assessment, a factor of 10 was used to convert the reported LD₅₀ to a LOAEL. A factor of 10 was used to convert a reported LOAEL to a NOAEL. If several toxicity values were reported for a receptor species, the most conservative value was used in the risk calculations regardless of toxic mechanism. Toxicity values obtained from long-term feeding studies were used in preference to those obtained from single dose oral studies. No other safety factors were incorporated into this risk assessment.

If the only toxicity datum available in the literature was a NOAEL, a factor of 10 was used to convert it to a LOAEL.

In some cases, contaminant doses were reported as part per million contaminant in diet. These were converted to daily intake in milligrams per kilogram body weight per day (mg/kg BW/day), by using the formula:

$$\text{Daily Intake (mg/kg/day)} = \text{Contaminant Dose (mg/kg diet)} \times \text{Ingestion Rate (kg/day)} \times 1/\text{Body Weight (kg)}$$

Models were formulated using only the results for the COPC analytes. The results for individual analytes were summed for BNAs, PCBs, LMWPAHs, and HMWPAHs. Metals were evaluated individually, and therefore required no sum. To determine TRVs for these contaminant classes, the lowest appropriate toxicity value was chosen to represent the toxicity of the entire class of that type of contaminant. In doing so, it was assumed that the total concentration of each class of contaminant consisted entirely of the most toxic member of that class.

Body weight, food consumption, water consumption, and incidental sediment ingestion values reported in the U.S. EPA Handbook of Wildlife Exposures (U.S. EPA 1993) were assumed to be valid, and equally weighted.

8.2 Sources of Uncertainty

This risk assessment evaluates exposure to contaminants through food ingestion. There are factors inherent in the risk assessment process which contribute to uncertainty and need to be considered

when interpreting results. Major sources of uncertainty include natural variability, error, and insufficient knowledge. Natural variability is an inherent characteristic of ecological receptors, their stressors, and their combined behavior in the environment. Biotic and abiotic parameters in these systems may vary to such a degree that the exposure of similar ecological receptors within the same system may differ temporally and spatially. Factors that contribute to temporal and spatial variability may be differences in an individual organism's behavior (within the same species), changes in the weather or ambient temperature, unanticipated interference from other stressors, differences between microenvironments, and numerous other factors.

A major source of uncertainty arises from the use of toxicity values reported in the literature which are derived from single-species, single-contaminant laboratory studies. Prediction of ecosystem effects from laboratory studies is difficult. Laboratory studies cannot take into account the effects of environmental factors which may add to the effects of contaminant stress. NOAELs were generally selected from studies using single contaminant exposure scenarios. Species utilizing the LCC site and the surrounding wetland are exposed to a variety of contaminants.

When COPC concentrations in water, sediment, and biota were calculated to evaluate their potential risk, conservative assumptions were made to account for "non-detect" results. For example, when an inorganic COPC was not detected in a particular sample, it was assumed that the actual concentration of that COPC in that sample was one-half the detection limit. Similarly, if an organic COPC was not detected in a sample, it was assumed that the actual concentration of that COPC in that sample was one-tenth the detection limit. These assumptions were also made when chemicals belonging to a common class of chemicals (e.g., PCBs) were summed to get a "total" concentration, as described previously. For example, if PCB-1254 was detected in a sample, but PCB-1248 was not, the "total PCB" concentration of that sample was calculated by summing the PCB-1254 concentration detected in the sample plus one-tenth of the detection limit of PCB-1248 for that sample. Therefore, even if a particular contaminant of concern was not detected in any of the samples for a particular matrix, data for that contaminant in that matrix were still evaluated in this risk assessment by assuming that the contaminant is actually present in each sample of that matrix at one-tenth (for organics) or one-half (for inorganics) of the detection limit for that particular contaminant.

In cases where a toxicity value has been converted by a factor of 10, the uncertainty associated with the absence of a directly relevant literature value was compounded by the uncertainty associated with a subjective mathematical adjustment.

Point estimates of exposure such as NOAELs, LOAELs, LD₅₀s, and mathematical means that are presented in the literature also have inherent variability, which is incorporated into the risk assessment. Additionally, because these values are statistically determined, they do not represent absolute thresholds; they are reflective of the experimental design. A reported LOAEL may not represent the lowest toxicity threshold for a species simply because lower concentrations were not tested in a study.

In addition, uncertainty associated with variability is introduced from the use of literature values for food ingestion rates, dietary compositions, and body weights. These values reported in the literature are from studies that may have been conducted at a time of year or in a location that does not necessarily give an accurate representation of the life histories of the receptor species in the LCC site area.

This risk assessment did not examine the contribution of dermal absorption or inhalation exposure as part of the exposure pathway. In contrast to the use of conservative assumptions, the error introduced into this risk assessment by the omission of these routes of exposure may be on the side of a less protective outcome. The relative contribution of this error to alter the outcome of the risk assessment is unknown at this time.

Some of the TRVs utilized for determination of risk (water and sediment quality benchmarks) in this assessment are below the MDLs for their respective contaminants. This is a function of the sample matrix, and the analytical methodologies utilized. Future studies should ensure that the MDLs are lower than the benchmark values.

The fish that were analyzed for tissue concentrations of COPCs were caught in fish traps, using cat food as bait. None of the fish were depurated prior to whole body tissue analysis. Therefore, there is uncertainty associated with the potential for COPCs to have been present in the cat food that was entrained in the fish's digestive tract.

Error can be introduced by use of invalid assumptions in the conceptual model. Conservative assumptions were made in light of the uncertainty associated with the risk assessment process. This was done to minimize the possibility of concluding that no risk is present when a threat actually does exist (e.g., elimination of false negatives). Whenever possible, risk calculations were based on conservative values. For example, NOAELs used to calculate HQs were the lowest values found in the literature, regardless of toxic mechanism.

9.0 CONCLUSIONS

There is risk to the aquatic and terrestrial communities living on or near the LCC Site. Site pond water, sediment, and soil caused significant toxic effects to organisms exposed in laboratory tests. The benthic community was in poor health in a 1998 survey. Additionally, the results of the food chain exposure models calculated that there is risk to receptor communities. These models focused on risks to organisms using the site as a food source. Therefore, the HQs calculated using these models used only contaminant exposure from food sources. Contaminant concentrations in water, sediment, and soil were excluded from these models. The risk to receptor organisms living on the site is likely underestimated, and there is likely risk to off-site communities preying on organisms that use the site.

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Tables

Table 4. Volatile Organic Compounds Detected in Water
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location					Regions III BTAG SD		U.S. EPA
	LCC-1 & LCC-2 Conc. (µg/L)	LCC-3 & LCC-4 Conc. (µg/L)	LCC-5 & LCC-6 Conc. (µg/L)	Lab Control ** Conc. (µg/L)	Freshwater Fauna µg/L	WQC-CCC µg/L		
1,1-Dichloroethane	U (1.0)	1.9	U (1.0)	U (5.0)	NA	NA		
1,2,4-Trimethylbenzene	U (1.0)	U (1.0)	4.6	U (5.0)	NA	NA		
1,3,5-Trimethylbenzene	U (1.0)	U (1.0)	1.3	U (5.0)	NA	NA		
Acetone	17	U (8.0)	17	400	NA	NA		
Benzene	U (1.0)	U (1.0)	1.8	U (5.0)	NA	NA		
Chlorobenzene	U (1.0)	U (1.0)	1.0	U (5.0)	NA	NA		
cis-1,2-Dichloroethene	U (1.0)	3.1	U (1.0)	U (5.0)	NA	NA		
Ethylbenzene	U (1.0)	U (1.0)	5.7	U (5.0)	NA	NA		
Naphthalene	U (1.0)	U (1.0)	4.0	U (5.0)	NA	NA		
o-Xylene	U (1.0)	U (1.0)	8.8	U (5.0)	NA	NA		
p&m-Xylene	U (1.0)	U (1.0)	20	U (5.0)	NA	NA		
Toluene	U (1.0)	U (1.0)	6.2	U (5.0)	NA	NA		
Vinyl Chloride	U (1.0)	1.9	U (1.0)	U (5.0)	NA	NA		

µg/L - micrograms per liter

U - not detected

J - estimated value

** - toxicity laboratory control water

U.S. EPA Region III BTAG Screening Levels (SL) for Aquatic Freshwater Fauna.

WQC-CCC = Water Quality Criteria - Criterion Continuous Concentration for Freshwater

Data collected January 2001

Table 5. Base, Neutral, and Acid Extractable Compounds Detected in Water
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Compound	Location					Regions III BTAG SL		U.S. EPA WQC-CCC
	LCC-1 & LCC-2	LCC-3 & LCC-4	LCC-5 & LCC-6	Lab Control **	Freshwater Fauna	µg/L	µg/L	
2,4-Dimethylphenol	U (10)	U (10)	19	U (10)	2120	NA	NA	NA
4-Methylphenol	U (10)	U (10)	10	U (10)	NA	NA	NA	NA
Bis(2-Ethylhexyl)phthalate	2.9 J	U (10)	17	2.8 J	NA	NA	NA	NA
Naphthalene	U (10)	U (10)	3.7 J	U (10)	100	NA	NA	NA

µg/L - micrograms per liter

U - not detected

J - estimated value

** - toxicity laboratory control water

U.S. EPA Region III BTAG Screening Levels (SL) for Aquatic Freshwater Fauna.

WQC-CCC = Water Quality Criteria Continuous Concentration for Freshwater

Data collected January 2001

Table 1. List of Contaminants of Potential Concern
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Contaminant	Surface Soil	Subsurface Soil	Sediment	Surface Water	Ground Water
Low Molecular Weight PAHs					
Acenaphthene	X	X	X		
Acenaphthylene	X	X	X		*
Anthracene	X	X	X		X
Fluorene	X	X	X		
Naphthalene	X	X	X		X
Phenanthrene	X	X	X		X
High Molecular Weight PAHs					
Benzo(a)anthracene	X	X	X		X
Benzo(a)pyrene	X	X	X		*
Benzo(b)fluoranthene	X	X	X		*
Benzo(g,h,i)perylene	X	X	X		*
Benzo(k)fluoranthene	X	X	*		*
Chrysene	X	X	X		*
Dibenz(a,h)anthracene	X	X	X		*
Fluoranthene	X	X	X		*
Indene(1,2,3-CD)pyrene	X	X			*
Pyrene	X	X	X		*
2-Methylnaphthalene	*	*	X		*
Other Semi-Volatile Compounds					
1,1-Dichloroethane			*		
1,2-Dichlorobenzene	X	X			*
1,2-Dichloroethane				*	*
1,2,4-Trichlorobenzene		X			*
1,3-Dichlorobenzene	*	*			*
1,4-Dichlorobenzene	X	X			*
2-Methylphenol	X	X	X		*
2-Nitrophenol					*
2-Chloronaphthalene		*			*
2,4-Dimethylphenol	X	X	X		*
2,6-Dinitrophenol		*			*
4-Chlorophenol			*		*
4-Chloro-3-methylphenol	*				*
4-Methylphenol	X	X		*	*
4-Methyl-2-pentanone		*		*	*
4-Nitrophenol			*		*
Benzic acid			X		*
Benzyl alcohol			X		*
bis(2-Chloroethyl)ether	*	*		*	*
bis(2-Ethylhexyl)phthalate	*	*	*		*
Butylbenzylphthalate	*	*	*		X
Carbonate	*	*	*		*
Dibenzofuran	*	*			*
Diethylphthalate	*	*			X
Dimethylphthalate	*	*		X	*
Di-n-butylphthalate	*	*	*	*	*
Di-n-octylphthalate	*	*	*		X
Hexachlorobenzene	*	*			*
Hexachlorobutadiene	*	*			*
Hexachlorocyclopentadiene	*	*	*		*
Isophorone	*	*	*		*
N-Nitrosodiphenylamine	*	*			*
Nitrobenzene	*	*			*
Pentachlorophenol	X	X	X		*
Phenol	X	X	X		X
Volatile Organic Compounds					
1,1,1-Trichloroethane	*	X			*
1,2-Dichloroethane	*	*	*	*	*
2-Butanone	*	*	*	*	*
2-Chloroethane	*	*	*	*	*
Axetone	*	*	*	*	*
Benzene	*	X	*	*	*
Carbon Disulfide	*	*	*	*	*
Chlorobenzene	*	X	*	*	X
Ethylbenzene	*	X	*	*	*
Methylene Chloride	*	X	*	*	X
Styrene	*	X	*	*	*
Tetrachloroethane	*	*	*	*	*
Toluene	*	X	*	*	X
Trichloroethane	*	*	*	*	*
Xylenes (Total)	*	X	*	*	X

X = Hazard Quotient of >1.0 for the contaminant, based on U.S. EPA Region III Screening Level benchmarks (U.S. EPA 1995)

* = Contaminant present, but no benchmark value available, based on U.S. EPA 1995.

Table constructed from Table 5 in Lake Calumet Cluster Site Screening Level Risk Assessment.

Table I (continued). List of Contaminants of Potential Concern
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Contaminant	Surface Soil	Subsurface Soil	Sediment	Surface Water	Ground Water
Pesticides/PCB					
4,4'-DDD	X	X	X		
4,4'-DDE	X	X	X		
4,4'-DDT	X	X	X	X	X
Aroclor 1242		X	X		
Aroclor 1248	X	X			
Aroclor 1254	X	X	X		
Aroclor 1260	X		X		
alpha-BHC	*	*	*		*
alpha-Chlordane		X	*	X	X
beta-BHC	*	*	*		*
delta-BHC	*	*	*	*	*
Dieldrin	X	X	*	X	X
Endosulfan I	*	*			X
Endosulfan II	*	*			X
Endosulfan Sulfate	*	*		*	*
Endrin				X	X
Endrin Aldehyde	*	*		*	*
Endrin Ketone	*	*			
gamma-Chlordane	X	X	*	X	X
Heptachlor	*	*		X	X
Heptachlor Epoxide		X	*		X
Methoxychlor	X	X			
Metals					
Aluminum			*	X	X
Antimony					X
Arsenic (total)			X		
Barium	X		*		
Beryllium			*		X
Cadmium	X	X	X	X	X
Calcium			*	*	*
Chromium (total)	X	X	X	*	*
Cobalt			*		
Copper			X	X	X
Iron			*	X	X
Lead	X	X	X	X	X
Magnesium			*	*	*
Manganese			*	X	X
Mercury	X	X	X		X
Nickel			X		X
Potassium			*	*	*
Selenium	X	X	*		X
Silver	X		X	X	X
Sodium			*	*	*
Thallium			*		
Vanadium			*		
Zinc				X	X

X = Hazard Quotient of >1.0 for the contaminant, based on U.S. EPA Region III Screening Level benchmarks (U.S. EPA 1995)

* = Contaminant present, but no benchmark value available, based on U.S. EPA 1995.

Table constructed from Table 5 in Lake Calumet Cluster Site Screening Level Risk Assessment.

Table 2. Target Analyte List Metals Detected in Water
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Metal	Location				Regions III BTAG SL	U.S. EPA
	LCC-1 & LCC-2	LCC-3 & LCC-4	LCC-5 & LCC-6	Lab Control **	Freshwater Fauna	WQC-CCC
	Conc. (µg/L)	Conc. (µg/L)	Conc. (µg/L)	Conc. (µg/L)	µg/L	µg/L
Aluminum	460	350	2700	U (50)	25	87
Arsenic	U (2.2)	U (2.2)	8.7	U (2.2)	874	150
Barium	32	59	160	U (5.0)	10000	NA
Calcium	46000 J	70000 J	81000 J	14000 J	NA	NA
Chromium	U (5.0)	6.3	59 J	U (5.0)	11	11
Cobalt	U (10)	U (10)	13	U (10)	35000	NA
Copper	U (10)	U (10)	21	U (10)	6.5	9
Iron	460 J	380	4600 J	U (25)	900	1000
Lead	4.6	3.2	23	U (2.2)	3.2	2.5
Magnesium	28000 J	46000 J	79000 J	12000 J	NA	NA
Manganese	130 J	82	480 J	U (5.0)	14500	NA
Nickel	U (10)	11	50	U (10)	160	52
Potassium	8100	26000	240000	2100	NA	NA
Sodium	20000 J	120000 J	1200* J	26000 J	NA	NA
Vanadium	U (10)	U (10)	19	U (10)	10	NA
Zinc	62 J	50	130 J	U (10)	110	120

* - concentration reported in milligrams per liter (mg/L)

µg/L - micrograms per liter

U - not detected

J - estimated value

** - toxicity laboratory control water (BT1-1a in analytical report)

U.S. EPA Region III BTAG Screening Levels (SL) for Aquatic Freshwater Fauna.

The Cr SL value assumes that all Cr is in the form Cr⁶⁺

The Fe SL value is for fish

WQC-CCC = Water Quality Criteria - Criterion Continuous Concentration for Freshwater

Data collected January 2001

Table 3. Pesticides/PCBs Detected in Water
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location					Regions III BTAG SL		U.S. EPA WQC-CCC µg/L
	LCC-1 & LCC-2	LCC-3 & LCC-4	LCC-5 & LCC-6	Lab Control **		Freshwater Fauna		
Aroclor 1242	Conc. (µg/L) U (0.3)	Conc. (µg/L) U (0.3)	Conc. (µg/L) 3.5	Conc. (µg/L) U (0.3)		µg/L		
Aroclor 1260	Conc. (µg/L) U (0.3)	Conc. (µg/L) U (0.3)	Conc. (µg/L) 0.21 J	Conc. (µg/L) U (0.3)		µg/L		

µg/L - micrograms per liter

U - not detected

J - estimated value

** - toxicity laboratory control water

U.S. EPA Region III BTAG Screening Levels (SL) for Aquatic Freshwater Fauna.

WQC-CCC - Water Quality Criteria - Criterion Continuous Concentration for Freshwater

Data collected January 2001

Table 6. *In-Situ* Water Quality Data
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Location	Temperature (°C)	pH (SU)	DO (mg/L)	Turbidity (NTU)	Conductivity (µS/cm)
LCC-1	0.5	7.1	2.7	7	681
LCC-2	0.0	7.3	6.7	25	486
LCC-3	0.0	7.0	5.0	35	1460
LCC-4	1.0	7.2	4.5	10	1639
LCC-5	0.0	7.9	2.5	51	8924
LCC-6	0.0	7.7	2.2	187	8934

°C = degrees Celsius

SU = standard units

DO = dissolved oxygen

mg/L = milligrams per liter

NTU = Nephelometric Turbidity Units

µS/cm = micro Siemens per centimeter

Data collected January 2001

Table 7. Target Analyte List Metals Detected in Sediment
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Metal	Location										Region III BTAG SL	
	LCC-1	LCC-2	LCC-3	LCC-5	LCC-6	LCC-7	Lab Control **	Fauna				
Aluminum	Conc. (mg/kg) 30000	Conc. (mg/kg) 8300	Conc. (mg/kg) 8700	Conc. (mg/kg) 13000	Conc. (mg/kg) 8200	Conc. (mg/kg) 6400	Conc. (mg/kg) 180	mg/kg				
Antimony	U (8.5)	U (6.0)	U (4.4)	U (15)	U (8.2)	17 J	U (5.2)	150				
Arsenic	5.6	6.6	5.0	6.5	5.3	41	U (2.3)	8.2				
Barium	350	51	78	100	56	710	U (0.86)	NA				
Beryllium	4.9	0.65	0.93	U (1.3)	U (0.68)	0.92	U (0.43)	NA				
Cadmium	1.4	U (0.50)	U (0.37)	1.4	0.70	9.4	U (0.43)	1.2				
Calcium	130000	49000	60000	82000	53000	140000	70	NA				
Chromium	63	31	74	67	47	320	U (0.43)	260				
Cobalt	6.4	10	8.0	13	10	15	U (0.86)	NA				
Copper	47 J	47 J	31 J	85 J	59 J	150 J	1.2	34				
Iron	34000	22000	25000	27000	19000	69000	170	NA				
Lead	170	83	75	140	70	960	U (3.4)	46.7				
Magnesium	13000	25000	24000	21000	21000	13000	U (43)	NA				
Manganese	4500	610	1200	950	530	7200	0.88	NA				
Mercury	0.16	0.13	0.07	0.20	0.12	2.5	U (0.04)	0.15				
Nickel	20 J	31 J	22 J	43 J	33 J	33 J	U (0.86)	20.9				
Potassium	2000	2100	1700	5700	3000	1100	U (170)	NA				
Selenium	2.0 J	U (1.1)	U (0.90)	U (2.9)	U (1.8)	U (1.4)	U (2.3)	NA				
Sodium	880	220 J	400	5600 J	2600 J	860	U (43)	NA				
Vanadium	31 J	26 J	25 J	47 J	30 J	83 J	U (1.7)	NA				
Zinc	390	220	110	310	170	730	3.4	150				

mg/kg - milligrams per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicity laboratory control sediment

U.S. EPA Region III BTAG Screening Levels (SL) for Fauna.

Data collected January 2001

Table 8. Pesticides/PCBs Detected in Sediment
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location							Region III BTAG SL	
	LCC-1 Conc. (µg/kg)	LCC-2 Conc. (µg/kg)	LCC-3 Conc. (µg/kg)	LCC-5 Conc. (µg/kg)	LCC-6 Conc. (µg/kg)	LCC-7 Conc. (µg/kg)	Lab Control ** Conc. (µg/kg)	Fauna µg/kg	
Aldrin	U (8.1)	U (6.0)	U (4.5)	U (15)	U (9.0)	37	U (4.4)	NA	
γ-Chlordane	15	U (6.0)	2.0 J	U (15)	U (9.0)	110	U (4.4)	NA	
α-Chlordane	U (8.1)	U (6.0)	U (4.5)	U (15)	U (9.0)	90 J	U (4.4)	NA	
Dieldrin	18	8.8	7.1	5.0 J	U (9.0)	3700	U (4.4)	NA	
p,p'-D D D	3600	15	4.1	21	14	4900 J	U (4.4)	16	
p,p'-D D E	1100	6.8	2.7	33 J	17	140	U (4.4)	2.2	
p,p'-D D T	68 J	U (6.0)	2.5 J	U (15)	U (9.0)	U (8.0)	U (4.4)	1.58	
Endrin	U (8.1)	U (6.0)	U (4.5)	U (15)	U (9.0)	4.8	U (4.4)	NA	
Endosulfan (I)	U (8.1)	U (6.0)	U (4.5)	36	U (9.0)	22	U (4.4)	NA	
Aroclor 1242	U (100)	U (74)	U (56)	3500	1300	670	U (55)	22.7	
Aroclor 1260	U (100)	U (74)	U (56)	530	310	360	U (55)	22.7	

µg/kg - micrograms per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicity laboratory control sediment

U.S. EPA Region III BTAG Screening Levels (SL) for Fauna.

Data collected January 2001

Table 9. Volatile Organic Compounds Detected in Sediment
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location							Region III BTAGS	
	LCC-1	LCC-2	LCC-3	LCC-5	LCC-6	LCC-7	Lab Control **	Fauna	
	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	µg/kg	
1,1,1-Trichloroethane	U (2.0)	U (1.8)	2.8	U (4.5)	U (2.4)	U (2.1)	U (1.3)	NA	
1,1-Dichloroethane	U (2.0)	U (1.8)	33	U (4.5)	U (2.4)	33	U (1.3)	NA	
1,2,4-Trimethylbenzene	U (2.0)	U (1.8)	2.0	120	U (2.4)	15	U (1.3)	NA	
1,2-Dichlorobenzene	U (2.0)	U (1.8)	U (1.3)	9.0	U (2.4)	3.1	U (1.3)	NA	
1,2-Dichloroethane	U (2.0)	U (1.8)	U (1.3)	U (4.5)	U (2.4)	4.0	U (1.3)	NA	
1,2-Dichloropropane	U (2.0)	U (1.8)	U (1.3)	U (4.5)	U (2.4)	2.2	U (1.3)	NA	
1,3,5-Trimethylbenzene	U (2.0)	U (1.8)	1.6	34	U (2.4)	U (2.1)	U (1.3)	NA	
1,4-Dichlorobenzene	U (2.0)	U (1.8)	U (1.3)	14	U (2.4)	U (2.1)	U (1.3)	NA	
2-Butanone	U (8.0)	U (7.1)	U (3.3)	17	U (9.8)	410	U (3.2)	NA	
4-Methyl-2-Pentanone	U (4.0)	U (3.6)	U (2.6)	U (9.1)	U (4.9)	310	U (2.6)	NA	
Acetone	U (16)	U (14)	U (11)	U (36)	U (20)	990 J	420	NA	
Benzene	U (2.0)	U (1.8)	7.7	15	3.4	89	U (1.3)	NA	
Carbon Disulfide	2.2	U (1.8)	U (1.3)	5.6	U (2.4)	U (2.1)	U (1.3)	NA	
Chlorobenzene	U (2.0)	U (1.8)	U (1.3)	14	U (2.4)	13	U (1.3)	NA	
Chloroethane	U (2.0)	U (1.8)	3.9 J	U (4.5)	U (2.4)	13	U (1.3)	NA	
cis-1,2-Dichloroethene	U (2.0)	U (1.8)	36	U (4.5)	U (2.4)	38	U (1.3)	NA	
Dichlorodifluoromethane	U (2.0)	U (1.8)	U (1.3)	U (4.5)	U (2.4)	U (2.1)	1.5	NA	
Ethylbenzene	U (2.0)	U (1.8)	21	120	2.9	310	U (1.3)	NA	
Isopropylbenzene	U (2.0)	U (1.8)	U (1.3)	13	U (2.4)	15	U (1.3)	NA	
Methylcyclohexane	U (2.0)	U (1.8)	2.4	U (4.5)	U (2.4)	32	U (1.3)	NA	
Naphthalene	U (2.0)	U (1.8)	U (1.3)	64	U (2.4)	3.3	U (1.3)	NA	
n-Propylbenzene	U (2.0)	U (1.8)	U (1.3)	9.4	U (2.4)	3.4	U (1.3)	NA	
o-Xylene	U (2.0)	U (1.8)	19	150	4.7	180	U (1.3)	NA	
p&m-Xylene	U (2.0)	U (1.8)	53	280	9.3	210	U (1.3)	NA	
Toluene	U (2.0)	U (1.8)	180	12	2.5	360	U (1.3)	NA	
trans-1,2-Dichloroethene	U (2.0)	U (1.8)	2.0	U (4.5)	U (2.4)	2.1	U (1.3)	NA	
Trichloroethene	U (2.0)	U (1.8)	2.4	U (4.5)	U (2.4)	11	U (1.3)	NA	
Vinyl Chloride	U (2.0)	U (1.8)	22 J	U (4.5)	U (2.4)	79 J	U (1.3)	NA	

µg/kg - micrograms per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicity laboratory control sediment

U.S. EPA Region III BTAG Screening Levels (SL) for Fauna.

Data collected January 2001

Table 10. Base, Neutral, and Acid Extractable Compounds Detected in Sediment
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location							Regions III BTAG SL	
	LCC-1	LCC-2	LCC-3	LCC-5	LCC-6	LCC-7	Lab Control **	Fauna	
	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	Conc. (µg/kg)	µg/kg	
2-Methylnaphthalene	U (4100)	U (3000)	U (2200)	U (7500)	U (4500)	4200 J	U (2200)	NA	
Benzo(a)anthracene	1100 J	1800 J	740 J	U (7500)	U (4500)	U (8000)	U (2200)	NA	
Benzo(a)pyrene	1300 J	2400 J	930 J	U (7500)	1300 J	2700 J	U (2200)	NA	
Benzo(b)fluoranthene	1200 J	2000 J	860 J	U (7500)	U (4500)	3400 J	U (2200)	3200	
Benzo(g,h,i)perylene	U (4100)	1600 J	670 J	U (7500)	U (4500)	2900 J	U (2200)	670	
Benzo(k)fluoranthene	1100 J	1900 J	940 J	U (7500)	U (4500)	2900 J	U (2200)	NA	
Bis(2-Ethylhexyl)phthalate	U (4100)	940 J	6100	6200 J	4700	14000	650 J	NA	
Butylbenzylphthalate	U (4100)	U (3000)	U (2200)	U (7500)	U (4500)	6900 J	U (2200)	NA	
Chrysene	1300 J	2100 J	880 J	U (7500)	2100 J	2600 J	U (2200)	384	
Fluoranthene	1700 J	3500	1400 J	2600 J	U (4500)	3500 J	U (2200)	600	
Indeno(1,2,3-cd)pyrene	U (4100)	1300 J	590 J	U (7500)	U (4500)	2400 J	U (2200)	600	
Isophorone	U (4100)	U (3000)	U (2200)	U (7500)	U (4500)	13000	U (2200)	NA	
Naphthalene	U (4100)	1100 J	U (2200)	U (7500)	U (4500)	2900 J	U (2200)	160	
Phenanthrene	U (4100)	2200 J	U (2200)	U (7500)	U (4500)	U (8000)	U (2200)	240	
Pyrene	1400 J	3200	1200 J	2300 J	U (4500)	2800 J	U (2200)	665	

µg/kg - micrograms per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicity laboratory control sediment

U.S. EPA Region III BTAG Screening Levels (SL) for Fauna.

Data collected January 2001

Totals were calculated using 1/10 of MDL for U values

Table 11. Target Analyte List Metals Detected in Soil
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

	Location						Regions III BTAG SL		Region III BTAG SL	
	SOIL-1	SOIL-2	SOIL-3	SOIL-4	SOIL-5	SOIL-6	Lab Control **	Flora mg/kg	Fauna mg/kg	
Metal				Concentration (mg/kg)						
Aluminum	10000	10000	6900	22000	11000	8900	840	1000	NA	
Antimony	U (6.0)	U (3.0)	8.2	U (4.6)	U (4.3)	7.9	U (6.8)	480	NA	
Arsenic	7.7	5.8	8.9 J	7.1	7.3	14	U (2.9)	328	NA	
Barium	280	76	810	250	120	190	12	440000	440000	
Beryllium	0.90	0.74	1.1	4.0	1.4	1.7	U (0.57)	20	NA	
Cadmium	0.67	0.86	5.2	0.44	1.3	6.9	U (0.57)	2500	NA	
Calcium	63000	69000	86000	150000	82000	9000	3300	NA	NA	
Chromium	140	360	480	710	780	42 J	1.9	20	7.5	
Cobalt	6.9	8.8	13	4.1	9.1	9.1 J	U (1.1)	100	200	
Copper	43	89	300	38	230	290	3.9	15000	NA	
Iron	18000	57000 J	44000	59000 J	81000	53000 J	720	3260000	12	
Lead	270	350	1300	33	160	2900	U (4.6)	2000	10	
Magnesium	21000	26000	14000	43000	25000	1600	120	0.44%	0.44%	
Manganese	1500	7700	7300	14000	8300	430	7.7	330000	330000	
Mercury	0.25	0.09	1.8	0.04	0.25	3.0	U (0.04)	58	58	
Nickel	22	64	33	28	280	54 J	U (1.1)	2000	NA	
Potassium	1700	1300	870	720	1400	480	U (230)	NA	NA	
Silver	U (0.50)	U (0.42)	U (0.44)	U (0.38)	U (0.36)	0.77	U (0.57)	0.0098	NA	
Sodium	370	230	420	690	400	560	U (57)	NA	NA	
Vanadium	31	110	110 J	250	240	22	4.0	500	58000	
Zinc	330	200	840	120	190	1800	17	10000	NA	

mg/kg - milligrams per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicity laboratory control soil

U.S. EPA Region III BTAG Screening Levels (SL) for Flora

Magnesium SL is measured in percent

Data collected January 2001

Table 12. Pesticides/PCBs Detected in Soil
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location					Regions III BTAG-SL Regions III BTAG-SL		
	SOIL-1	SOIL-2	SOIL-3	SOIL-4	SOIL-5	SOIL-6	Lab Control **	Fauna µg/L
Pesticides								
Aldrin	U (4.4)	1.7 J	U (5.0)	U (4.4)	3.4 J	430 J	U (3.8)	100
D-D DDE	4.3 J	U (4.2)	U (5.0)	U (4.4)	U (4.1)	U (5.0)	U (3.8)	NA
D-D DDE	3100	2.1 J	25	U (4.4)	9.1	200 J	U (3.8)	100
D-D DDE	75	2.7	68	1.4 J	5.2	330 J	U (3.8)	100
D-D DDE	36 J	6.3 J	U (5.0)	U (4.4)	U (4.1)	U (5.0)	U (3.8)	100
Dieldrin	49	5.6	39	1.0 J	4.5	20	U (3.8)	100
Endosulfan (I)	U (4.4)	4.6	U (5.0)	U (4.4)	4.7	U (5.0)	U (3.8)	NA
Endosulfan (II)	9.3	U (4.2)	U (5.0)	U (4.4)	U (4.1)	U (5.0)	U (3.8)	NA
γ-Chlordane	54	U (4.2)	23	U (4.4)	U (4.1)	14	U (3.8)	100
γ-Chlordane	53	U (4.2)	56	U (4.4)	U (4.1)	280 J	U (3.8)	100
Heptachlor Epoxide	U (4.4)	U (4.2)	U (5.0)	U (4.4)	U (4.1)	U (5.0)	U (3.8)	100
PCBs								
Aroclor 1242	U (55)	120	340	26 J	99	13000	U (48)	NA
Aroclor 1260	140	120	590	19 J	170	1700	U (48)	NA

µg/kg - micrograms per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicology laboratory control soil

U.S. EPA Region III BTAG Screening Levels (SL) for Flora and Fauna

Data collected January 2001

Table 13. Volatile Organic Compounds Detected in Soil
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location						Regions III BTAG SL	
	SOIL-1	SOIL-2	SOIL-3	SOIL-4	SOIL-5	SOIL-6	Lab Control	Flora
1,1-Dichloroethane	Conc. (µg/kg) U (1.3)	Conc. (µg/kg) U (1.3)	Conc. (µg/kg) 2.7	Conc. (µg/kg) U (1.3)	Conc. (µg/kg) U (1.2)	Conc. (µg/kg) U (1.4)	Conc. (µg/kg) U (1.2)	µg/kg NA
Acetone	11	24	2.5	51	3.5	U (1.1)	5.71	NA
Dichlorodifluoromethane	U (1.3)	U (1.3)	U (1.3)	U (1.3)	U (1.2)	U (1.4)	1.7	NA
Methylene Chloride	6.5	1.6	2.2	1.4	U (1.2)	U (1.4)	U (1.2)	NA
Trichlorofluoromethane	U (1.3)	U (1.3)	U (1.3)	U (1.3)	U (1.2)	U (1.4)	1.6	NA

µg/kg - micrograms per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicity laboratory control soil

U.S. EPA Region III BTAG Screening Levels (SL) for Flora

Data collected January 2001

Table 14. Base, Neutral, and Acid Extractable Compounds Detected in Soil
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Compound	Location						Regions III BTAGSL	
	SOIL-1	SOIL-2	SOIL-3	SOIL-4	SOIL-5	SOIL-6	Lab Control **	Flora µg/kg
	Concentration (µg/kg)							
	BNAs							
3,3'-Dichlorobenzidine	U (2200)	U (2100)	1100 J	U (2200)	U (2100)	U (2500)	U (1900)	NA
Bis(2-Ethylhexyl)phthalate	820 J	15000	15000	U (2200)	1100 J	1600 J	1100 J	NA
Butylbenzylphthalate	U (2200)	U (2100)	1900 J	U (2200)	U (2100)	U (2500)	U (1900)	NA
Di-n-butylphthalate	U (2200)	U (2100)	2900 J	U (2200)	U (2100)	650 J	U (1900)	NA
Isophorone	U (2200)	U (2100)	6200	U (2200)	U (2100)	U (2500)	U (1900)	NA
Phenol	U (2200)	U (2100)	1500 J	U (2200)	U (2100)	U (2500)	U (1900)	NA
	HAPs							
Benzo(a)anthracene	5900	1500 J	U (5000)	U (2200)	880 J	700 J	U (1900)	100
Benzo(a)pyrene	7100	2000 J	U (5000)	U (2200)	1300 J	910 J	U (1900)	100
Benzo(b)fluoranthene	6600	1800 J	U (5000)	U (2200)	1200 J	870 J	U (1900)	100
Benzo(g,h,i)perylene	4400	1700 J	U (5000)	U (2200)	1100 J	700 J	U (1900)	100
Benzo(k)fluoranthene	6300	1900 J	U (5000)	U (2200)	1200 J	810 J	U (1900)	100
Chrysene	6300	1600 J	U (5000)	U (2200)	1100 J	930 J	U (1900)	100
Fluoranthene	13000	2400	2200 J	U (2200)	1400 J	1100 J	U (1900)	100
Indeno(1,2,3-cd)pyrene	4000	1400 J	U (5000)	U (2200)	890 J	U (2500)	U (1900)	100
Pyrene	10000	2000 J	U (5000)	U (2200)	1300 J	990 J	U (1900)	100
	LMWPAHs							
2-Methylnaphthalene	U (2200)	U (2100)	1500 J	U (2200)	U (2100)	U (2500)	U (1900)	NA
Acenaphthylene	880 J	U (2100)	1100 J	U (2200)	U (2100)	U (2500)	U (1900)	100
Anthracene	1800 J	U (2100)	U (5000)	U (2200)	U (2100)	U (2500)	U (1900)	100
Carbazole	740 J	U (2100)	U (5000)	U (2200)	U (2100)	U (2500)	U (1900)	NA
Fluorene	870 J	U (2100)	U (5000)	U (2200)	U (2100)	U (2500)	U (1900)	NA
Naphthalene	U (2200)	U (2100)	1900 J	U (2200)	U (2100)	U (2500)	U (1900)	100
Phenanthrene	7600	1100 J	1300 J	U (2200)	730 J	U (2500)	U (1900)	100

µg/kg - micrograms per kilogram (dry weight)

U - not detected

J - estimated value

** - toxicity laboratory control soil

U.S. EPA Region III BTAG Screening Levels (SL) for Flora

Data collected January 2001

Table 15. Target Analyte List Metals Detected in Fish and Crayfish Tissue
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Metal	Fish		Crayfish	
	LHL1 East mg/kg	LHL1 West mg/kg	LHL1 Crayfish mg/kg	LHL2 N&S mg/kg
Aluminum	190	580	550	1300
Antimony	U (0.58)	U (0.56)	U (0.42)	U (0.45)
Arsenic	U (1.2)	U (1.1)	1.2 J	2 J
Barium	44	46	130	240
Beryllium	U (0.58)	U (0.56)	U (0.42)	U (0.45)
Cadmium	U (1.5)	U (1.4)	U (1.1)	U (1.1)
Calcium	42000	40000	91000	130000
Chromium	1.9	2.6	2.6	6.0
Cobalt	U (2.9)	U (2.8)	U (2.1)	2.3
Copper	5.7	5.8	110	140
Iron	370	680	880	1500
Lead	2.0	3.1	5.3	9.8
Magnesium	1900	2100	3400	3500
Manganese	30 J	46 J	330 J	390 J
Mercury	U (0.21)	U (0.20)	U (0.15)	U (0.21)
Nickel	U (2.9)	U (2.8)	3.3	3.8
Potassium	13000	13000	9700	7900
Selenium	2.4	2.4	1.1	1.3
Silver	U (1.5)	U (1.4)	U (1.1)	U (1.1)
Sodium	5700	5600	8700	7000
Thallium	U (1.2)	U (1.1)	U (0.84)	U (0.89)
Vanadium	U (2.9)	U (2.8)	2.4	4.7
Zinc	250	250	140	130

mg/kg - milligrams per kilogram (dry weight)

U - not detected

Data collected April 2001

Table 16. TAL Metals Detected in Earthworms Exposed to Site Soil
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Metal	Location											
	TIME-0	LC	SOIL-1	SOIL-2	SOIL-3	SOIL-4	SOIL-5	SOIL-6				
	Conc mg/kg	Conc mg/kg	Conc mg/kg	Conc mg/kg	Conc mg/kg	Conc mg/kg	Conc mg/kg	Conc mg/kg				
Aluminum	56	430	1000	960	760	400	240	2000				
Antimony	U (0.97)	U (0.77)	U (0.78)	0.81	3.9	U (0.78)	U (0.83)	1.6				
Arsenic	4.7	18	27	27	29	27	30	21				
Barium	2.4	2.0	24	9.6	110	8.4	5.6	54				
Beryllium	U (0.97)	U (0.77)	U (0.78)	U (0.77)	U (0.76)	U (0.78)	U (0.83)	U (0.83)				
Cadmium	U (2.4)	5.4	5.7	5.1	5.2	6.0	5.5	13				
Calcium	4300	4200	7900	6800	12000	6500	5000	5800				
Chromium	U (2.4)	8.4	5.6	11	46	12	4.9	15				
Cobalt	U (4.8)	7.2	6.8	7.1	7.2	6.7	6.5	7.0				
Copper	10	18	27	50	57	32	30	160				
Iron	300	540	1900	2500	3500	1500	1000	7400				
Lead	U (0.97)	1.3	22	26	170	2.5	4.8	120				
Magnesium	1400	910	2800	2800	2600	2000	1900	1500				
Manganese	24	15	95	140	290	220	120	120				
Mercury	U (0.25)	U (0.2)	U (0.19)	0.44	0.53	U (0.19)	U (0.21)	6.2				
Nickel	U (4.8)	U (3.9)	4.7	6.7	10	U (3.9)	7.9	18				
Potassium	12000	12000	12000	12000	12000	11000	12000	13000				
Selenium	2.9	8.8	9.0	8.9	8.5	9.3	8.7	8.9				
Silver	U (2.4)	U (1.9)	U (2.0)	U (1.9)	U (1.9)	U (1.9)	U (2.1)	U (2.1)				
Sodium	7700	6700	6900	6800	7200	6700	6900	8200				
Thallium	U (0.97)	U (0.77)	U (0.78)	U (0.77)	U (0.76)	U (0.78)	U (0.83)	U (0.83)				
Vanadium	U (4.8)	U (3.9)	U (3.9)	U (3.8)	6.0	4.6	U (4.2)	6.3				
Zinc	170	140	160	170	260	140	150	610				

mg/kg - milligrams per kilogram (dry weight)
U - not detected

LC - Laboratory Control earthworms

Tissue values for SOIL-1, SOIL-2, SOIL-3, SOIL-4, SOIL-5, and SOIL-6 are mean values from test replicates A through E.

Table 17. Pesticides/PCBs Detected in Fish and Crayfish Tissue
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Parameter	Fish		Crayfish	
	LHL1 EAST	LHL1 WEST	LHL1	LHL2 N&S
	Conc. µg/kg	Conc. µg/kg	Conc. µg/kg	Conc. µg/kg
p,p'-DDE	69	79	U (16)	U (14)
p,p'-DDD	55	62	U (16)	U (14)
Aroclor 1254	1900	1900	860	U (180)
Aroclor 1260	740	890	160 J	U (180)

µg/kg - micrograms per kilogram (dry weight)

U - not detected

J - estimated value

Data collected April 2001

Table 18. PCBs Detected in Earthworms Exposed to Site Soil
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Compound	Location							
	Time 0	LC	SOIL 1	SOIL 2	SOIL 3	SOIL 4	SOIL 5	SOIL 6
	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Aroclor 1248	U (1300)	U (530)	U (470)	U (510)	1100	U (490)	U (580)	48000
Aroclor 1254	U (1300)	U (530)	U (470)	U (510)	1000	160 J	330 J	22000

µg/kg - micrograms per kilogram (dry weight)

U - not detected

LC - Laboratory Control earthworms

J - estimated value

Table 19. Base, Neutral, and Acid Extractable Compounds Detected in Fish and Crayfish Tissue
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Tissue Type	Fish		Crayfish	
Location	LHL1 East	LHL1 West	LHL1	LHL2 N&S
Compound	µg/kg	µg/kg	µg/kg	µg/kg
Diethylphthalate	3500	U (9500)	U (8000)	U (7100)
Bis(2-Ethylhexyl)phthalate	4900	3600	1700	2600

Data collected April 2001

µg/kg - micrograms per kilogram (dry weight)

U - not detected

Table 20. Survival and Growth of Amphipods (*Hyaella azteca*) Exposed to Site Sediments
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Sample Location	% Survival	Mean Dry Weight (mg)	OET
Laboratory Control	88.75	0.052	N/A
LCC-1	83.75	0.113	no
LCC-2	31.25	0.045	yes
LCC-3	70	0.060	no
LCC-5	40	0.101	yes
LCC-6	1.25	0.005	yes
LCC-7	95	0.118	no

mg = milligrams

OET = Observed Effect Treatment

N/A = not applicable

Test conducted February 2001

Table 21. Survival and Growth of Fathead Minnows (*Pimephales promelas*) Exposed to Site Water
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Sample Location	% Survival	Mean Dry Weight (mg)	OET
Laboratory Control	97.5	0.273	N/A
Aerated Control	95	0.249	no
LCC-5 & LCC-6	0	N/A	yes
LCC-1 & LCC-2	100	0.231	no
LCC-3 & LCC-4	67.5	0.275	yes

mg = milligrams

OET = Observed Effect Treatment

N/A = not applicable

Test conducted February 2001

Table 22. Survival and Growth of Earthworms (*Eisenia foetida*) Exposed to Site Soil
 Lake Calumet Cluster Site
 Chicago, Illinois
 November 2001

Sample Location	% Survival	OET for Survival	Avg. Weight Loss (mg)	OET for Growth
Artificial Soil	98	N/A	843.2	N/A
Soil-1	98	no	1144.32	no
Soil-2	92	no	1142.04	no
Soil-3	78	yes	1169.09	N/A
Soil-4	91	no	910.7	no
Soil-5	92	no	630.95	no
Soil-6	93	no	210.87	no

mg = milligrams

OET = Observed Effect Treatment

N/A = not applicable

Test conducted February 2001

Table 23. Survival and Growth of Ryegrass (*Lolium perenne*) Exposed to Site Soil
Lake Calumet Cluster Site
Chicago, Illinois
November 2001

Sample Location	Parameter	Effect
	% Survival	OET
Artificial Soil	100	N/A
Soil-1	96	no
Soil-2	96	no
Soil-3	24	yes
Soil-4	84	no
Soil-5	100	no
Soil-6	92	no
	Avg. Shoot Length (mm)	OET
Artificial Soil	141.88	N/A
Soil-1	89.08	yes
Soil-2	81.71	yes
Soil-3	N/A	N/A
Soil-4	52.42	yes
Soil-5	61.33	yes
Soil-6	116.26	yes
	Avg. Shoot Wet Weight (mg)	OET
Artificial Soil	405.3	N/A
Soil-1	76.7	yes
Soil-2	80.9	yes
Soil-3	N/A	N/A
Soil-4	36.3	yes
Soil-5	44.1	yes
Soil-6	143.5	no
	Avg. Shoot Dry Weight (mg)	OET
Artificial Soil	81.2	N/A
Soil-1	25.5	no
Soil-2	20.9	no
Soil-3	N/A	N/A
Soil-4	11.3	yes
Soil-5	16.2	yes
Soil-6	34	no
	Avg. Root Wet Weight (mg)	OET
Artificial Soil	637.3	N/A
Soil-1	101.3	yes
Soil-2	76.7	yes
Soil-3	N/A	N/A
Soil-4	84.4	yes
Soil-5	101.7	yes
Soil-6	286	yes
	Avg. Root Dry Weight (mg)	OET
Artificial Soil	59.5	N/A
Soil-1	16	yes
Soil-2	13.2	yes
Soil-3	N/A	N/A
Soil-4	12.2	yes
Soil-5	10.4	yes
Soil-6	34.5	no

% = percent

Avg. = average

OET = Observed Effect Treatment

mm = millimeters

mg = milligrams

N/A = not applicable

Test conducted February 2001

COPC	Yellow Headed		Shrew	
	HQ LOAEL	EL	HQ LOAEL	HQ NOAEL
Total Pesticides	NA	1	NA	NA
Total PCBs	14.88	0	52.14	104.28
Total BNAs	0.00	6	0.00	0.00
Total LMW PAHs	0.00	0	0.00	0.00
Total HMW PAHs	0.00	0	0.00	0.00
Total Chlordanes	0.00	0	0.00	0.00
Total DDE, DDD, DDT	0.00	0	0.00	0.00
Dieldrin	0.00	0	0.00	0.00
BHC	NA	1	NA	NA
Aluminum	3.14	2	0.95	1.89
Arsenic	0.14	3	0.27	2.72
Antimony	NA	5	3.82	38.19
Barium	0.07	6	1.76	17.61
Beryllium	NA	1	0.01	0.05
Cadmium	0.36	8	0.38	3.83
Calcium	NA	1	NA	NA
Chromium	2.40	0	0.04	0.08
Cobalt	0.04	1	0.03	0.12
Copper	0.76	6	0.33	0.49
Iron	NA	0	0.55	1.56
Lead	2.96	8	0.17	1.74
Magnesium	NA	1	0.02	0.04
Manganese	0.01	4	0.08	0.27
Mercury	1.70	9	2.86	14.28
Nickel	0.04	0	0.02	0.03
Potassium	NA	1	NA	NA
Selenium	2.83	6	2.39	3.94
Silver	0.01	4	0.03	0.31
Sodium	1.62	4	0.10	1.96
Thallium	0.09	0	0.04	0.45
Vanadium	0.01	8	0.23	2.33
Zinc	1.10	5	0.20	9.99

NA = not available: one or more critical pi
 PCB=polychlorinated biphenyl
 BNA=base, neutral, and acid extractable
 LMW PAH=low molecular weight polycy
 HMW PAH=high molecular weight polycy
 DDE, DDD, DDT=dichlorodiphenyl-trichl
 COPC=contaminant of potential concern
 LOAEL=lowest observed adverse effect le
 NOAEL=no observable adverse effect leve

Lake Calumet Cluster Site

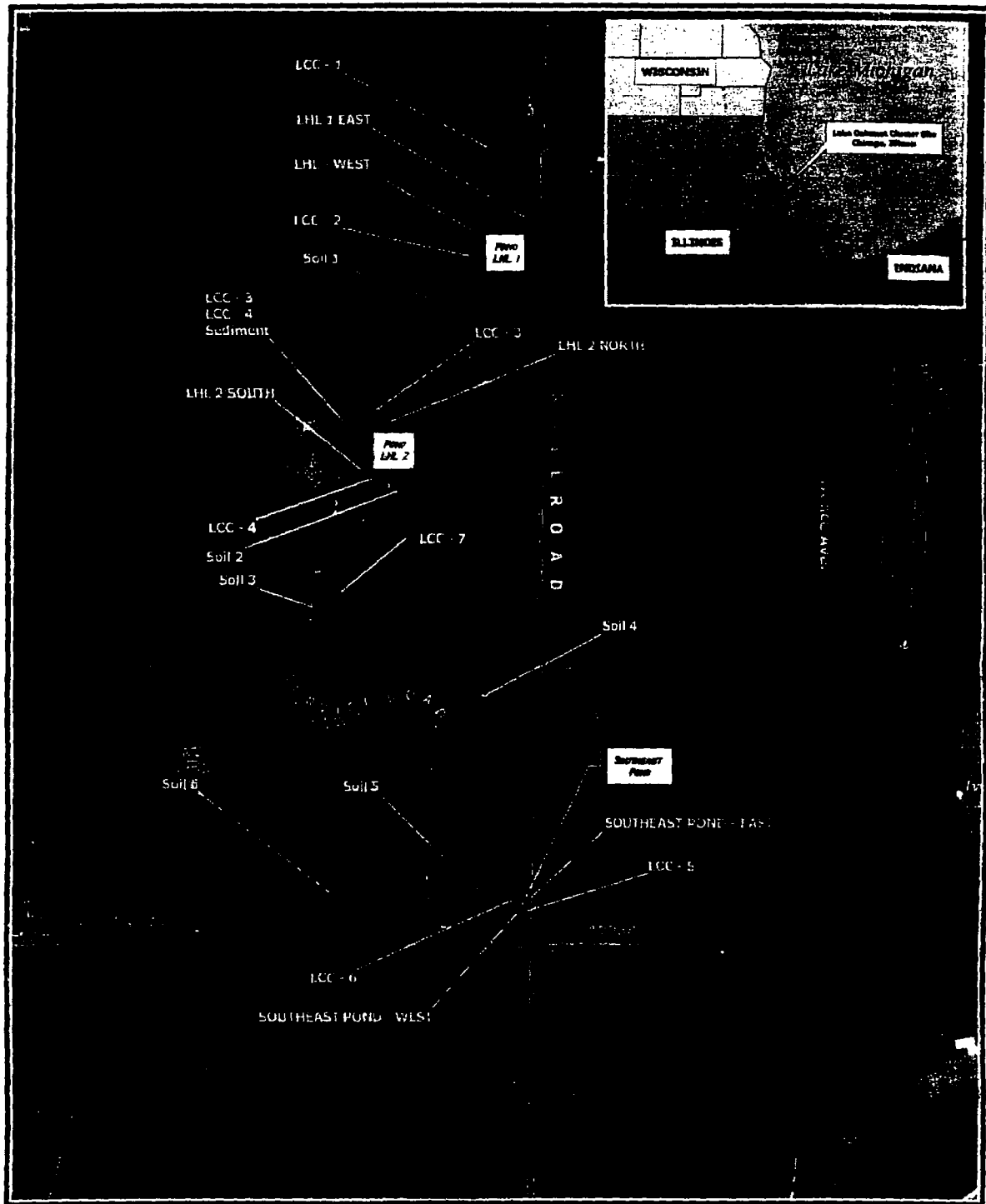


Figure 1
Site Location Map
Lake Calumet Cluster Site
Chicago, Illinois
November, 2001

U.S. EPA Environmental Response Team Center
Response Engineering and Analytical Contract
68-C99-223
W.A.# R1A00053

C

Detailed Cost Estimate Information

Derived Capital Costs for the Lake Calumet Cluster Site

Subject: Lake Calumet Cluster
 Location: Calumet City, Illinois
 Base Year: 2006
 Size of Site: 90 acres
 Active Construction Period: 32 months

ITEM 1 GENERAL

Derived Cost C1a - Field Overhead and Oversight

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Trailers - 3 units	96	MO	\$ -	\$ -	\$ 229.03	\$ 229.03	\$ 21,987	HCCD 01520-500-0250/0700
Temporary Electric Hookup - 3	3	EA	\$ 686.75	\$ -	\$ 820.32	\$ 1,507.07	\$ 4,521	HCCD 01510-050-0040
Storage Boxes - 3 units	96	MO	\$ -	\$ -	\$ 82.58	\$ 82.58	\$ 7,928	HCCD 01520-500-1250
Site Superintendent	32	MO	\$13,991.25	\$ -	\$ -	\$13,991.25	\$ 447,720	HCCD 01310-700-0260
Clerk	32	MO	\$ 2,975.92	\$ -	\$ -	\$ 2,975.92	\$ 95,229	HCCD 01310-700-0020
Project Manager	32	MO	\$15,101.67	\$ -	\$ -	\$15,101.67	\$ 483,253	HCCD 01310-700-0200
Field Engineer	32	MO	\$ 9,238.67	\$ -	\$ -	\$ 9,238.67	\$ 295,637	HCCD 01310-700-0120
Telephone Service - 6 lines	192	MO	\$ -	\$ -	\$ 231.23	\$ 231.23	\$ 44,396	HCCD 01520-550-0140
Internet Service	64	MO	\$ -	\$ -	\$ 44.04	\$ 44.04	\$ 2,819	Engineer Estimate
Portable Toilet - 6 units	192	MO	\$ -	\$ -	\$ 178.20	\$ 178.20	\$ 34,214	HCCD 01 54 33-40-6410
Field Office Lights/HVAC - 3	96	MO	\$ -	\$ -	\$ 121.12	\$ 121.12	\$ 11,628	HCCD 01520-550-0160
Field Office Equipment	96	MO	\$ -	\$ -	\$ 159.66	\$ 159.66	\$ 15,327	HCCD 01520-550-0100
Field Office Supplies	96	MO	\$ -	\$ -	\$ 99.00	\$ 99.00	\$ 9,504	HCCD 01520-550-0120
C1a Subtotal							\$ 1,474,200	

Derived Cost C1b - Plans and Submittals

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Construction Operations Plan, QC Plan, Safety Plan, other submittals, and testing	1	LS	\$ -	\$ -	\$ -	\$ 100,000	\$ 100,000	Engineering Estimate
C1b Subtotal							\$ 100,000	

Derived Cost C1c.1 - Pre-Construction Surveying

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
HCCD Crew A-7, 3-man field	7	DAY	\$ 1,911.42	\$ 64.19	\$ -	\$ 1,975.61	\$ 13,829	HCCD Crews
HCCD Crew A-7, 2-man off.	7	DAY	\$ 1,160.30	\$ -	\$ 0.41	\$ 1,160.71	\$ 8,125	HCCD Crews
C1c.1 Subtotal							\$ 22,000	

Derived Cost C1c.2 - Surveying During Construction

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
HCCD Crew A-7, 2-man field ¹	416	DAY	\$ 1,160.30	\$ 64.19	\$ 0.41	\$ 1,224.89	\$ 509,600	HCCD Crews
C1c.2 Subtotal							\$ 509,600	

¹ Assumes 32 months working 60% of the time

Derived Cost C1c.3 - Post-Construction Surveying

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
HCCD Crew A-7, 3-man field	7	DAY	\$ 1,911.42	\$ 64.19	\$ -	\$ 1,975.61	\$ 13,829	HCCD Crews
HCCD Crew A-7, 2-man off.	7	DAY	\$ 1,160.30	\$ -	\$ 0.41	\$ 1,160.71	\$ 8,125	HCCD Crews
C1c.3 Subtotal							\$ 22,000	

Derived Capital Costs for the Lake Calumet Cluster Site

ITEM 2 GENERAL SITE WORK

Derived Cost C2a - Clearing

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Selective clearing, with dozer and brush rake, light	90	ACRE	\$ 100.45	\$ 101.20	\$ -	\$ 201.65	\$ 18,100	HCCD 02230-200-0500
C2a Subtotal							\$ 18,100	

Derived Cost C2b - Demolition (3 small buildings)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Demolish Structure	1	LS	\$ -	\$ -	\$ -	\$50,000.00	\$ 50,000	Engineering Estimate
C2b Subtotal							\$ 50,000	

Derived Cost C2c - Relocate Utilities

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Relocate Utility	1	LS	\$ -	\$ -	\$ -	#####	\$ 100,000	Engineering Estimate
C2c Subtotal							\$ 100,000	

ITEM 3 GAS COLLECTION SYSTEM

Derived Cost C3a - Trenching (4' Depth)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
trench, 3/4 CY Backhoe	42,000	CY	\$ 3.59	\$ 1.75	\$ -	\$ 5.34	\$ 224,206	HCCD 02315-610-0110
C3a Subtotal							\$ 224,206	

Derived Cost C3b - Collection Pipe

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
10' Length, 4" Diameter	94,000	LF	\$ 4.08	\$ -	\$ 2.79	\$ 6.87	\$ 645,337	HCCD 02530-780-2000
C3b Subtotal							\$ 645,337	

Derived Cost C3c - Trench Infill (use free slag material)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Fill, by dozer, no compaction	42,000	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 76,987	HCCD 02315-520-0020
C3c Subtotal							\$ 76,987	

Derived Cost C3d - Geotextile

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Fabric, laid in trench, PP	52,000	SY	\$ 0.37	\$ -	\$ 1.52	\$ 1.89	\$ 98,203	HCCD 02620-300-0100
C3d Subtotal							\$ 98,203	

Derived Capital Costs for the Lake Calumet Cluster Site

ITEM 4 EARTHWORK AND GEOSYNTHETIC

Derived Cost C4a - Grading Layer (~2.5' thick)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Excavation, Bulk Bank Measure - Front end loader, wheel mounted, 3 CY capacity	346,000	CY	\$ 0.74	\$ 0.30	\$ -	\$ 1.04	\$ 358,110	HCCD 02315-424-1601
For loading onto trucks, add 15%	346,000	CY	\$ 0.11	\$ 0.04	\$ -	\$ 0.16	\$ 53,717	HCCD 02315-424-0020
Haul soil, 60 CY rear or bottom dump, 1/2 mile round trip, 3.4 loads per hr.	346,000	CY	\$ 0.35	\$ 1.38	\$ -	\$ 1.72	\$ 596,331	HCCD 02315-490-2140
Spread dumped material; by dozer, no compaction	346,000	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 633,872	HCCD 02315-520-0020
Finish grading slopes	436,000	SY	\$ 0.12	\$ 0.06	\$ -	\$ 0.18	\$ 77,600	HCCD 02310-100-3300
Compaction, Sheepsfoot, 12" lifts (x2), 4 passes	872,000	SY	\$ 0.33	\$ 0.36	\$ -	\$ 0.69	\$ 602,552	HCCD 02315-310-5720
C4a Subtotal							\$ 2,322,200	

Derived Cost C4b - Permeable Soil Layer (2' thick)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Permeable soil, stockpiled on-site	290,667	CY	\$ -	\$ -	\$ -	\$ 9.24	\$ 2,686,703	Vendor Quote
Excavation, Bulk Bank Measure - Front end loader, wheel mounted, 3 CY capacity	290,667	CY	\$ 0.74	\$ 0.30	\$ -	\$ 1.04	\$ 300,840	HCCD 02315-424-1601
For loading onto trucks, add 15%	290,667	CY	\$ 0.11	\$ 0.04	\$ -	\$ 0.16	\$ 45,126	HCCD 02315-424-0020
Haul soil, 60 CY rear or bottom dump, 1/2 mile round trip, 3.4 loads per hr.	290,667	CY	\$ 0.35	\$ 1.38	\$ -	\$ 1.72	\$ 500,964	HCCD 02315-490-2140
Spread dumped material; by dozer, no compaction	290,667	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 532,501	HCCD 02315-520-0020
Finish grading slopes	436,000	SY	\$ 0.12	\$ 0.06	\$ -	\$ 0.18	\$ 77,600	HCCD 02310-100-3300
Compaction, Sheepsfoot, 12" lifts (x3), 4 passes	1,308,000	SY	\$ 0.33	\$ 0.37	\$ -	\$ 0.69	\$ 908,144	HCCD 02315-310-5720
C4b Subtotal							\$ 5,051,900	

Derived Capital Costs for the Lake Calumet Cluster Site

Derived Cost C4c - Impervious Layer (3' thick; use free DOT material)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Excavation, Bulk Bank Measure - Front end loader, wheel mounted, 3 CY capacity	436,000	CY	\$ 0.74	\$ 0.30	\$ -	\$ 1.04	\$ 451,260	HCCD 02315-424-1601
For loading onto trucks, add 15%	436,000	CY	\$ 0.11	\$ 0.04	\$ -	\$ 0.16	\$ 67,689	HCCD 02315-424-0020
Haul soil, 60 CY rear or bottom dump, 1/2 mile round trip, 3.4 loads per hr.	436,000	CY	\$ 0.35	\$ 1.38	\$ -	\$ 1.72	\$ 751,446	HCCD 02315-490-2140
Spread dumped material; by dozer, no compaction	436,000	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 798,752	HCCD 02315-520-0020
Finish grading slopes	436,000	SY	\$ 0.12	\$ 0.06	\$ -	\$ 0.18	\$ 77,600	HCCD 02310-100-3300
Compaction, Sheepfoot, 12" lifts (x3), 4 passes	1,308,000	SY	\$ 0.33	\$ 0.37	\$ -	\$ 0.69	\$ 908,144	HCCD 02315-310-5720

C4c Subtotal \$ 3,054,900

Derived Cost C4d - Geonet

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Install 200 mil geocomposite, biplanar, double-sided 8 oz.	3,924,000	SF	\$ -	\$ -	\$ -	\$ 0.40	\$ 1,569,600	Vendor Quote

C4d Subtotal \$ 1,569,600

Derived Cost C4e - Sand Drainage Layer (6" thick)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Sand material, stockpiled on-site	73,000	CY	\$ -	\$ -	\$ -	\$ 9.24	\$ 674,757	Vendor Quote
Load soil from stockpile onto dumptruck; front end loader, 5 CY bucket	73,000	CY	\$ 0.33	\$ 0.30	\$ -	\$ 0.63	\$ 45,625	HCCD 02315-210-7080
Haul soil, 60 CY rear or bottom dump, 1/2 mile round trip, 3.4 loads per hr.	73,000	CY	\$ 0.35	\$ 1.38	\$ -	\$ 1.72	\$ 125,816	HCCD 02315-490-2140
Spread dumped material; by dozer, no compaction	73,000	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 133,736	HCCD 02315-520-0020
Finish grading slopes	436,000	SY	\$ 0.12	\$ 0.06	\$ -	\$ 0.18	\$ 77,600	HCCD 02310-100-3300

C4e Subtotal \$ 1,057,500

Derived Cost C4f - Cobble Drain-Biotic Layer (8" thick; use free slag material)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Load soil from stockpile onto dumptruck; front end loader, 5 CY bucket	97,000	CY	\$ 0.33	\$ 0.30	\$ -	\$ 0.63	\$ 60,625	HCCD 02315-210-7080
Haul soil, 60 CY rear or bottom dump, 1/2 mile round trip, 3.4 loads per hr.	97,000	CY	\$ 0.35	\$ 1.38	\$ -	\$ 1.72	\$ 167,180	HCCD 02315-490-2140
Spread dumped material; by dozer, no compaction	97,000	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 177,704	HCCD 02315-520-0020

C4f Subtotal \$ 405,500

Derived Capital Costs for the Lake Calumet Cluster Site

Derived Cost C4g - Geotextile

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Install 8 oz geotextile filter fabric	436,000	SY	\$ -	\$ -	\$ -	\$ 0.90	\$ 392,400	Vendor Quote
<i>C4g Subtotal</i>							\$ 392,400	

Derived Cost C4h - Demarcation Fabric Installation

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Install HDPE Fabric	436,000	SY	\$ -	\$ -	\$ -	\$ 0.62	\$ 270,300	Vendor Quote
<i>C4h Subtotal</i>							\$ 270,300	

Derived Cost C4i - Cover Layer (1.5' thick; use free DOT material)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Excavation, Bulk Bank Measure - Front end loader, wheel mounted, 3 CY capacity	218,000	CY	\$ 0.74	\$ 0.30	\$ -	\$ 1.04	\$ 225,630	HCCD 02315-424-1601
For loading onto trucks, add 15%	218,000	CY	\$ 0.11	\$ 0.04	\$ -	\$ 0.16	\$ 33,845	HCCD 02315-424-0020
Haul soil, 60 CY rear or bottom dump, 1/2 mile round trip, 3.4 ds per hr.	218,000	CY	\$ 0.35	\$ 1.38	\$ -	\$ 1.72	\$ 375,723	HCCD 02315-490-2140
Spread dumped material; by dozer, no compaction	218,000	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 399,376	HCCD 02315-520-0020
Finish grading slopes	436,000	SY	\$ 0.12	\$ 0.06	\$ -	\$ 0.18	\$ 77,600	HCCD 02310-100-3300
Compaction, Sheepfoot, 12" lifts (x2), 4 passes	872,000	SY	\$ 0.33	\$ 0.37	\$ -	\$ 0.69	\$ 605,430	HCCD 02315-310-5720
<i>C4i Subtotal</i>							\$ 1,717,600	

Derived Cost C4j - Soil (Silty Loam) Layer (4' thick to minimize infiltration)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Silty loam (silt, sand and clay), stockpiled on-site	581,333	CY	\$ -	\$ -	\$ -	\$ 12.33	\$ 7,169,778	Vendor Quote
Load soil from stockpile onto dumptruck; front end loader, 5 CY bucket	581,333	CY	\$ 0.33	\$ 0.30	\$ -	\$ 0.63	\$ 363,333	HCCD 02315-210-7080
Haul soil, 60 CY rear or bottom dump, 1/2 mile round trip, 3.4 loads per hr.	581,333	CY	\$ 0.35	\$ 1.38	\$ -	\$ 1.72	\$ 1,001,928	HCCD 02315-490-2140
Spread dumped material; by dozer, no compaction	581,333	CY	\$ 0.82	\$ 1.01	\$ -	\$ 1.83	\$ 1,065,003	HCCD 02315-520-0020
<i>C4j Subtotal</i>							\$ 9,600,000	

Derived Cost C4k - ET Vegetation

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Seeding	90	ACRE	\$ 84.66	\$ -	\$ 1,627.81	\$ 1,712.47	\$ 154,122	Vendor Quote
Plantings	90	ACRE	\$ -	\$ -	\$ -	\$ 5,284.60	\$ 475,614	Vendor Quote
Fertilizer	90	ACRE	\$ -	\$ -	\$ -	\$ 500.00	\$ 45,000	Vendor Quote
<i>C4k Subtotal</i>							\$ 674,700	

Derived Capital Costs for the Lake Calumet Cluster Site

EM 5 MISCELLANEOUS

Derived Cost C5a - Drain Layer Collection/Conveyance

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Construct Drainage Layer	Job	LS	\$ -	\$ -	\$ -	\$ 335,000	\$ 335,000	Engineer Estimate
C5a Subtotal							\$ 335,000	

Derived Cost C5b - Biosolids (6", tilled into cover; use free material)

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Tilling topsoil, 6" deep	3,920	MSF	\$ 2.13	\$ 0.73	\$ -	\$ 2.86	\$ 11,200	HCCD 02910-710-6100
C5b Subtotal							\$ 11,200	

Derived Cost C5c - Seeding

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Hydroseed	90	ACRE	\$ -	\$ -	\$ -	\$ 1,400.00	\$ 126,000	Vendor Quote
C5c Subtotal							\$ 126,000	

Derived Cost C5d - Fence

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	REFERENCE
Chain Link Fence, 6' high	7,200	LF	\$ 6.77	\$ 0.74	\$ 5.83	\$ 13.33	\$ 95,990	HCCD 02820-140-0100
C5d Subtotal							\$ 95,990	

References:

R.S. Means, 2006, Heavy Construction Cost Data 20th Annual Edition (HCCD).

Project	Lake Calumet Cluster
Location	Calumet City, Illinois
Base Year	2006
interest rate.	5%
O&M Period (years)	30

Derived Cost 01a - Gas Collection Condensate Disposal

<i>Ola Subtotal</i>	<i>\$1,900</i>
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Derived Cost O2a - Annual Groundwater Monitoring

O2a Subtotal	\$15,700
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Derived Cost O3a - Cover Inspection

03a Subtotal	\$4,400
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03h Subtotal	\$10,500
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03c Subtotal	\$11,300
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03d Subtotal	\$15,000
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03e Subtotal	\$2,600
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